

# *FINAL REPORT*

## CALIFORNIA HIGH-SPEED RAIL CORRIDOR EVALUATION



*Prepared for:*



*Prepared by:*



*In Association with:*

**SYSTRA Consulting, Inc.**  
**The Duffey Company**  
**Valley Research and Planning Associates**

**DECEMBER 30, 1999**

### HSR - 98004

# FINAL REPORT CALIFORNIA HIGH-SPEED RAIL CORRIDOR EVALUATION

**Prepared For:**  
**California High-Speed Rail Authority**

Prepared By:  
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In Association with:  
**SYSTRA Consulting, Inc.**  
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# INTRODUCTION



# I - INTRODUCTION



## 1.1 PURPOSE

In September of 1998, the California High-Speed Rail Authority commissioned this Corridor Evaluation study to assess and evaluate the viability of various corridors throughout the State for implementation as part of a statewide high-speed rail system. The corridors were evaluated on the basis of capital, operating and maintenance costs, travel times and engineering, operational and environmental constraints. The corridors were compared and evaluated on a regional basis and as part of a statewide system. The findings of this corridor evaluation study comprise an important component in the development of a system of corridors and also provide a basis for ridership, revenue and financial studies. The system of corridors will be the basis for preparing an environmental impact statement and impact report for a comparison of alternatives.

This report documents the assumptions, parameters and methodologies and presents the results and findings used in this corridor evaluation study.

## 1.2 BACKGROUND

The California Intercity High Speed Rail Commission (Commission) was established in 1993 by Senate Concurrent Resolution (SCR) 6 to investigate the feasibility of high speed rail (HSR) for California, specifically, a system connecting the San Francisco Bay Area with Los Angeles with extensions to San Diego and Sacramento. To address this question of feasibility, the Commission successfully conducted a series of technical studies encompassing ridership and revenue forecasts, economic impact and benefit cost analyses, institutional and financing options, corridor evaluation and environmental constraints analyses, and preliminary engineering feasibility studies. Based on these





studies, the Commission determined that HSR is technically, environmentally and economically feasible and set forth recommendations for the technology, corridors, financing, and operation of the system.

A new High Speed Rail Authority (Authority) was created in 1996 by Senate Bill 1420 with the mandate to direct the development and implementation of intercity high speed rail service in California. The Authority is responsible for the preparation of a proposed financial plan that would lead to construction and operation of a high speed rail network for the state consistent with and continuing the work of the Commission. The Authority has until the end of the year 2000 to secure funding for the system otherwise it will sunset. Towards this goal, the Authority is proceeding with the preparation of the plan and an extensive public outreach program.

Gaining the consensus and support of the local agencies and the public across the state will be crucial to the success of the Authority. In this regard, there are still several technical issues to be addressed. These issues are generally related to corridor alignment, station placement, and system integration with existing and planned transportation facilities. Some of these issues were raised during and immediately subsequent to the previous corridor evaluation studies. For instance, several issues were raised regarding service between Los Angeles and San Diego, primarily due to the limited number of extension corridor options that could be addressed in that study. Other issues have been raised as local jurisdictions have taken the time to consider the ramifications of the proposed HSR system. Certainly more questions and issues will arise as the Authority moves ahead with their planning efforts.

Addressing these issues will be paramount to gaining public and agency support for the construction of a statewide high speed rail network.

### 1.3 ORGANIZATION

Subsequent to this introduction, this report is organized in five key chapters as follows:

*Assumptions and Parameters* – this section documents key system parameters and assumptions, as applied in this corridor evaluation study. The parameters include the definition of the Commission proposed system (Baseline) which was the starting point for the Authority's analysis, design guidelines, operating assumptions, capital and operating unit costs and other planning assumptions.

*Regional Corridor Evaluation* – this chapter defines and describes the regional corridor alternatives studied and presents the evaluation of these alternatives with respect to capital and operating costs, travel times, and constraints (environmental, engineering, and operating).

*Overall Corridor Comparison* – this chapter defines and describes the statewide corridor alternatives studied and presents the evaluation of these alternatives with respect to capital and operating costs, travel times, and constraints (environmental, engineering, and operating).

*Operating Strategy Development* – this chapter describes the development of a conceptual operating plan for the California HSR, including frequency and types of service. The potential for commuter service in addition to the intercity service is also addressed and analyzed.

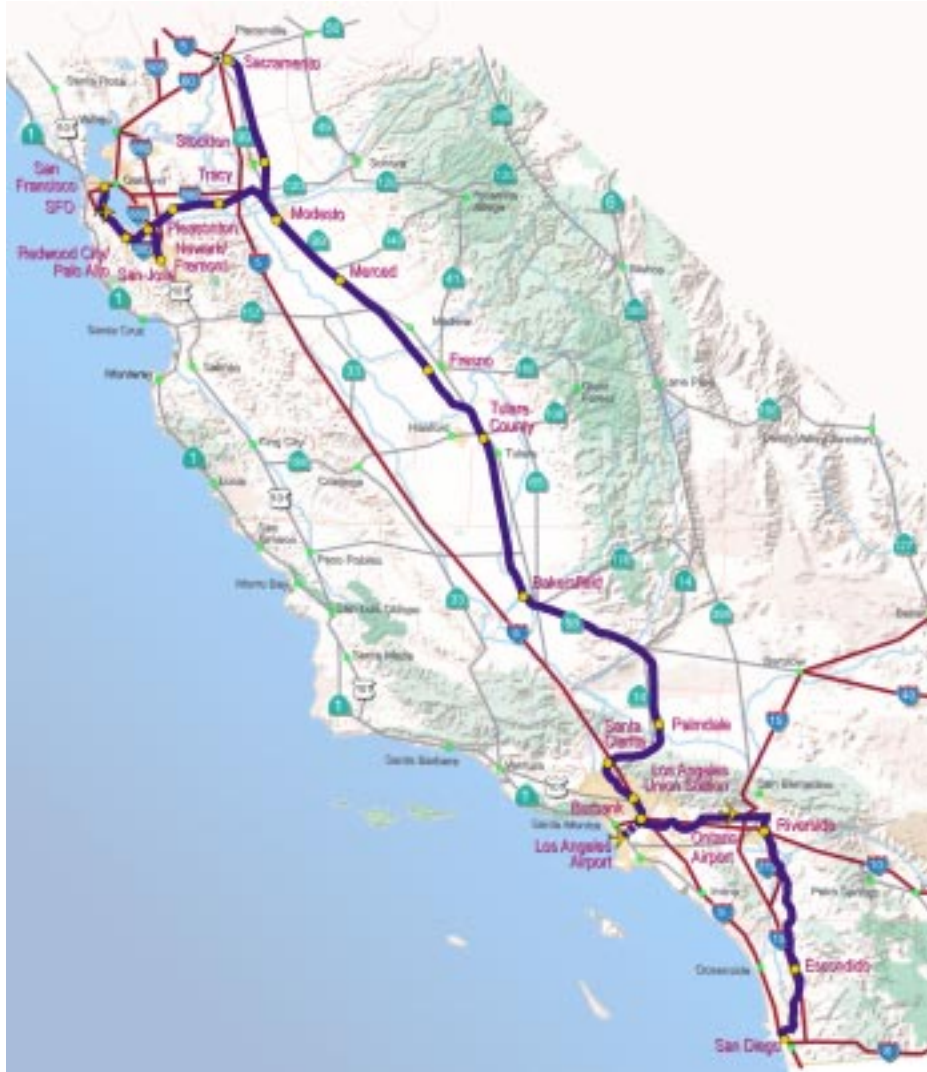
*Implementation Issues* – this chapter addresses key issues associated with the implementation of the recommended system. These issues include planning and project development, project staging/phasing, project procurement and institutional issues.

# ASSUMPTIONS AND PARAMETERS



## II - ASSUMPTIONS AND PARAMETERS

**EXHIBIT 2-1**  
**PREVIOUS COMMISSION PROPOSED CORRIDOR (BASELINE)**



The purpose of this chapter is to present a summary of key system parameters and assumptions, as applied in this corridor evaluation study. This chapter defines the overall features of the Commission proposed system to serve as a “Baseline” or datum line for our comparisons. This chapter also defines key parameters including design guidelines, operating assumptions, capital and operating unit costs and other planning assumptions. These assumptions and parameters were reviewed by the Authority directors and staff, and the consultant team as well as peer reviewed, prior to application in the technical studies.

The material presented in this chapter incorporates research by the project team, information obtained on the Authority’s European High-Speed Rail Tour, and the input received from HSR operators, manufacturers and consultants

### **2.1 COMMISSION PROPOSED SYSTEM (BASELINE)**

The statewide high-speed rail corridor system recommended by the previous High-Speed Rail Commission is almost 680 miles (1100 km) long and links all of California’s major population centers: Sacramento, the San Francisco Bay Area, the Central Valley, Los Angeles, and San Diego (*Exhibit 2-1*). The Commission’s recommended corridor served as a starting point or *Baseline alternative* for the studies presented in this report; thus, it is important to define this system early in this report.



**EXHIBIT 2-2  
BASELINE SYSTEM CHARACTERISTICS**

As shown in Exhibit 2-1, the Los Angeles-San Francisco Bay Area segment extends from Los Angeles Union Station in Southern California to northern termini in the downtown of San Francisco and San Jose. The route crosses the Tehachapi Mountains via an Antelope Valley route and serves the Central Valley with an alignment in the vicinity of SR-99. South of Stockton, the route enters the Bay Area via the Altamont Pass. Once within the Bay Area, the main line branches at Newark with one branch continuing across a newly constructed Dumbarton rail bridge and up the Peninsula (using the Joint Powers Board right-of-way) to downtown San Francisco. The other branch continues south from Newark to San Jose. An alignment from Stockton connects Sacramento to the system. Service between Los Angeles and San Diego utilizes an inland route approximating the I-215/I-15 corridor and serving San Bernardino and Riverside Counties.

The corridor recommended by the Commission was defined as an electrified, double tracked and completely grade-separated passenger rail system with maximum speeds exceeding 200 miles per hour. *Exhibit 2-2* summarizes some of the key characteristics of this system.

	VHS System	Maglev System
<b>Capital Cost (1999 \$billion)</b>		
Los Angeles - San Francisco/San Jose	\$13.4	\$19.2
Los Angeles - San Diego	6.6	8.5
Stockton - Sacramento	1.8	2.5
<b>Sub Total</b>	<b>21.8</b>	<b>30.2</b>
Vehicle Cost	1.2	1.1
Support Facilities	0.3	0.3
<b>Total</b>	<b>23.3</b>	<b>31.6</b>
<b>Operations and Maintenance Costs</b>		
Annual Train-miles (millions)	15.8	15.8
Annual O&M Costs (millions)	\$357	\$364
<b>Length (miles/km)</b>		
Los Angeles - San Francisco/San Jose	460 / 740	Same
Los Angeles - San Diego	158 / 254	Same
Stockton - Sacramento	58 / 93	Same
<b>Total</b>	<b>676 / 1088</b>	<b>Same</b>
<b>Express Travel Times (hours : minutes)</b>		
Los Angeles - San Francisco	2:52	2:05
Los Angeles - San Jose	2:33	1:52
Los Angeles - San Diego	1:11	0:56
Los Angeles - Sacramento	2:34	1:54
San Francisco - Sacramento	1:21	1:02
Fresno - San Jose	1:04	0:47
Fresno - Los Angeles	1:33	1:09
Fresno - San Francisco	1:23	0:60
Bakersfield - San Francisco	1:54	1:22
Bakersfield - Los Angeles	1:00	0:46
Sacramento - San Jose	1:03	0:50



**EXHIBIT 2-3**  
**STEEL WHEEL ON RAIL (VHS)**  
**TGV, FRANCE**



**EXHIBIT 2-4**  
**STEEL WHEEL ON RAIL (VHS)**  
**ICE-3, GERMANY**

### Technology

Two technology groups were utilized to develop the design criteria and to simulate performance characteristics for the California HSR corridors. The groups were classified by their speed (both currently obtainable speeds as well as targeted speeds that may result from further research and development) and by similar design characteristics.

The Very High Speed (VHS) group includes trains capable of maximum operating speeds near 220 mph (350 km/h) utilizing steel-wheel-on-rail technology (*Exhibits 2-3 and 2-4*). With its high speeds, a dedicated, fully grade-separated right-of-way is required for safety and operational issues with more stringent alignment requirements than those needed for lower speed lines. All VHS systems in operation use electric propulsion with overhead catenary and include the Train à Grande Vitesse (TGV) in France operating at up to 186 mph and the InterCity Express (ICE) in Germany which operates at 155 mph.

The Magnetic Levitation (Maglev) group utilizes either attractive or repulsive magnetic forces to lift and propel the train along a guideway (*Exhibit 2-5*). Current systems under development are designed for maximum operating speeds above that of VHS technology, 310 mph (500 km/h) and beyond. Magnetic levitation allows the vehicles to hover or "float" a small distance above the guideway, thereby eliminating friction and rolling resistance. Due to the unique, guideway required, the shared use of track by conventional steel wheel systems is infeasible although right-of-way may be shared. While there are currently no Maglev systems in revenue service, the success of the German Transrapid system's 20-mile test guideway has led to its certification for use in Germany and a Hamburg-Berlin line is approved for construction with expected service by 2006.





### **Speeds**

The proposed technology is focused on the next generation of VHS and Maglev trains to provide both frequent service and fast travel times. It is anticipated that trains will travel at maximum operating speeds near 220 mph (350 km/h) for VHS technology and 310 mph (500 km/h) for Maglev. Average operating speeds will, of course, be lower, around 155 mph (250 km/h) for VHS technology and 185 mph (300 km/h) for Maglev. Speeds in urban areas are constrained to a maximum around 125 mph (200 km/h) due to physical and environmental constraints. These speeds allow for express travel times between San Francisco and Los Angeles of about two and one half to three hours with VHS technology and two to two and one-half hours with Maglev, depending on the corridor.

### **Electrification**

An electrical propulsion system is necessary to provide the performance characteristics (e.g. speed and acceleration) required to be competitive with other modes of travel in California. Both of the technology groups utilize electric propulsion systems.

### **Double Track/Guideway**

Both technology groups require a dual track/guideway system to safely support the ridership volumes, frequency of service, scheduling flexibility and delay recovery required for this California corridor.

### **Grade Separation**

Due to the safety and performance requirements, there will be no grade crossings permitted on the HSR line. No vehicles or pedestrians will be permitted to cross the tracks, which would expose them to a possible collision with a train. In addition, the right-of-way will be fully access controlled (fenced) in areas of high-speed operation to avoid intrusion by pedestrians, wildlife and livestock.



**EXHIBIT 2-6  
DESIGN SPEEDS**

	VHS		Maglev	
<b>Top Speed</b>	180 - 220 mph (290 - 350 km/h)		220 - 310 mph (350 - 500 km/h)	
<b>Average Speed</b>	125 - 155 mph (200 - 250 km/h)		155 - 220 mph (250 - 350 km/h)	
<b>Acceleration</b>	mph/s	(km/h/s)	mph/s	(km/h/s)
0 - 62 mph	1.3	2.1	1.9	3.2
62 - 124 mph	1.0	1.6	1.9	3.2
124 - 186 mph	0.6	1.0	1.5	2.5
186 + mph mph/s	0.6	1.0	1.1	1.8
<b>Deceleration</b>	mph/s	(km/h/s)	mph/s	(km/h/s)
	1.6	1.9	1.8	2.9

**EXHIBIT 2-7  
HORIZONTAL ALIGNMENT**

	VHS	Maglev
<b>Minimum tangent length</b>	2.22 V	Not required
<b>Equilibrium superelevation<sup>1</sup>(Ee)</b>	$\frac{3.96 V^2}{R}$	$\sin^{-1} \left( \frac{V^2}{14.95R} \right)$
<b>Max Ee</b>	7 "	16°
<b>Unbalance superelevation (Eu)</b>	Ee-Ea	Ee-Ea
<b>Max Eu</b>	5 "	5°
<b>Minimum length of circular curve (Lc)</b>	2.22 V	2.22 V
<b>Minimum radius</b>	650' (200m)	1148' (350m)
<b>Spiral length<sup>1</sup> (Le) - Greater of:</b>	1.38 Ea V	1.47 Ea V
<b>(None required if Ls&lt;0.01 R)</b>	0.98 Eu V	56.05 V sin Eu
	62 Ee	66 Ee

**Ea** = actual superelevation (inches or degrees), **Ee** = equilibrium superelevation (inches or degrees),

**Eu** = unbalanced superelevation (inches or degrees), **Lc** = minimum length of circular curve (feet),

**Le** = spiral length (feet), **Ls** = minimum length of transition spiral (feet), **Lt** = minimum tangent length (feet),

**R** = radius (feet), **V** = velocity (mph)

**(1)** Specific comments were made by VHS and Maglev manufacturers regarding superelevation and spiral length formulae. More information has been requested to resolve these comments and is forthcoming. The differences will not have a significant effect on the alignments generated in previous studies.

## 2.2 DESIGN PARAMETERS

This section presents the design parameters including speeds, geometry and clearances applied in the current corridor evaluation studies for each of the candidate technologies. The criteria presented are based on accepted engineering practice, the criteria and experiences of other railway and high speed rail systems, and recommendations of VHS and Maglev manufacturers. The alignment criteria and clearances, as set forth, were established with the following objectives:

- ◆ Maximum system safety
- ◆ Acceptable passenger comfort
- ◆ Minimum wear on rails and wheels for rail technologies
- ◆ Compatibility with railcar characteristics
- ◆ Maximum operating speed and efficiency.

### Design Speeds

*Exhibit 2-6* presents the range of maximum operational speeds and acceleration/deceleration characteristics assumed for the two technology groups under consideration, allowing for expanded capabilities in the next generation of VHS equipment. Because of variations in performance and equipment characteristics, each group has its own geometric design criteria.

### Horizontal Alignment

The horizontal alignment design parameters are based on passenger comfort; limiting the lateral force on the passenger. To limit the discomfort caused by excessive lateral force, the track is superelevated (tilted) toward the inside of the curves, minimum lengths of tangents and curves are required for VHS, and spiral transition curves are applied to assure a gradual introduction of lateral force. The steady state lateral forces are



limited to 0.1g or 3.2 ft/s<sup>2</sup> (1 m/s<sup>2</sup>) in the design parameters described below for both technology groups. *Exhibit 2-7* includes formulae for determining superelevation and minimum lengths of tangents, curves, and transition curves for the two technology groups.

### Vertical Alignment

The vertical alignment, also known as the profile, traces the elevation of the top of rail or top of the Maglev guideway running surface. Maximum profile gradients are based on trainset performance. The length of vertical curves is governed by the vertical force that passengers can comfortably experience in profile crests and sags. According to standard U.S. passenger rail practices, the allowable forces in sags (downward 0.03g) is slightly greater than that for crests (upward 0.02g) and are practically the same from a standpoint of minimum and desirable criteria. There is also a minimum length of profile tangent and vertical curves, which prevent a roller coaster effect in profiles.

Included in *Exhibit 2-8* are recommended maximum gradients for main lines, secondary tracks and yards, and stations. Also included are formulae for computing radii of vertical curves and minimum curve and tangent lengths.

For VHS technology, the desired maximum gradient is 3.5%, although train set manufacturers claim that the technology is capable of 5% grades. An alignment using 5% grades would have a significant reduction in both tunnel lengths and capital costs. Some of the drawbacks of 5% grades include significantly higher energy usage and reduced speeds due to the steep sustained grades. Furthermore, 5% grades have yet

**EXHIBIT 2-8**  
**VERTICAL ALIGNMENT**

	VHS	Maglev
<b>Length of constant grade (Lt)</b>		
Desirable	4.38 V	not required
Minimum	2.22 V	not required
<b>Gradient (in %)</b>		
Mainline Tracks:		
(desirable maximum)	3.5	not required
(absolute maximum)	5.0	10.0 <sup>(1)</sup>
Stations: (desirable minimum)	0.0	Same
(absolute maximum)	0.25	Same
Yards and secondary tracks:	0.0	Same
Storage and transfer tracks:	0.0	Same
<b>Vertical curve radius (R)</b>		
Crest	3.33 V <sup>2</sup>	Same (2)
Sag	2.22 V <sup>2</sup>	
<b>Length of vertical curve (LVC)</b>		
Desirable	4.38 V	Same (2)
Minimum	2.22 V	
(increase 50% if in horizontal curve)		

**L<sub>t</sub>** = length of constant grade (feet), **LVC** = length of vertical curve (feet),  
**R** = vertical curve radius (feet), **V** = velocity (mph)

(1) Combined effects of steep grades and horizontal curves on passenger comfort will need to be considered in design phase of project.

(2) Comments were received from Transrapid International regarding geometric formulae. More information has been requested.

**EXHIBIT 2-9  
CLEARANCES**

	VHS	Maglev <sup>(1)</sup>
<b>Horizontal</b> Centerline of track/guideway to face of fixed object	10 ft 4 in (3.1m) @350 km/h	9 ft 5 in (2.8m) @400 km/h 10 ft 4 in (3.1m) @500 km/h
<b>Vertical</b> Top of rail/guideway to face of fixed object (minimum)	21 ft (6.4 m)	12 ft 2 in (3.7 m)
<b>Track/guideway centerline spacing</b> Double track center to center distance	13 ft 9 in (4.2m) @270 km/h	14 ft 5 in (4.4m) @300 km/h
Minimum	<sup>(2)</sup> 15 ft 8 in (4.7 m) @ 350 km/h	16 ft 8 in ( 5.1 m) @500 km/h
<b>Emergency walkway width (minimum clear)</b>	30 in	Same

(1) Transrapid Maglev

(2) TGV system requires 4.5 m, ICE requires 4.7m @ 350 km/h.

**EXHIBIT 2-10  
MINIMUM RIGHT-OF-WAY REQUIREMENTS**

Type of Section	VHS	Maglev
At-Grade/Cut-and-Fill/Retained Fill	50 ft (15.2 m)	47 ft (14.3 m)
Aerial Structure	50 ft (15.2 m)	49 ft (15 m)
Tunnel (Double Track)	67 ft (20.4 m)	67 ft (20.4 m)
Tunnel (Twin Single Track)	120 ft (36.6 m)	120 ft (36.6 m)
Trench/Box Section	70 ft (21.3 m)	73 ft (22.2 m)

to be tested in revenue service and freight operations would be limited.

### **Clearance Requirements**

Adequate clearances assure the safe passage of trains, access to disabled trains, safe conditions for maintenance personnel and passenger evacuation. Minimum clearances are specified in *Exhibit 2-9*.

### **Right-of-Way Requirements**

The minimum right-of-way limits for typical operating sections of the HSR system are shown in *Exhibit 2-10*. These limits represent the minimum right-of-way required for basic implementation of a specific operating section. Other factors such as topography, cut-and-fill slopes, drainage, retaining walls, service roads, utilities, technology (VHS or Maglev) operating speeds, and construction methods also influence the extent of the required right-of-way envelope. Typical cross-sections for each technology group are included in Appendix A.

For cost estimating purposes three general parameters were followed: (1) a minimum right of way corridor of 50 feet (15.2 m) has been assumed in congested corridors; (2) a 100 foot (30.4 m) corridor has been assumed in less developed areas to allow for drainage, future expansion and maintenance needs; and (3) a wider corridor was assumed in variable terrain to allow for cut and fill slopes.

For comparison purposes, the width of right of way corridor required for a new freeway section with comparable capacity is over 220 feet.



## Stations

The selection of stations is one of the key considerations that will affect the relative effectiveness and efficiency of the proposed high-speed rail service. The number and spacing between stations and local access to these sites are critical to the trade-off between system accessibility to riders and line haul travel time. The location of the stations with respect to travel markets and transportation infrastructure, the ease of intermodal access to and from the station, and the travel time to and from the station can be critical determinants of system performance.

Several key factors were considered in the identification of potential station stops along the system including speed, cost, ridership potential, operating policy, local access times, intermodal connectivity and the distribution of population and major destinations along

the route. All intermediate stations incorporate siding tracks for stopping trains, allowing through movement of express trains. This assumption directly addresses speed and operating issues. In general, stations are spaced following the pattern of urban centers (about 50 miles in rural areas), with overall average spacing at approximately 30 miles and in metropolitan areas an average spacing of 15 miles. Closer spacing would have significant impacts on the ability to operate express and local traffic on the same dual track system in these areas due to substantial differences in operating speeds.

### Station Design Parameters

The stations are assumed to have high-level boarding platforms to facilitate loading and unloading of passengers as well as meet requirements for disabled passengers per the Americans with Disabilities Act (ADA). Station platforms are assumed to have a minimum length equivalent to that of a 10 car train, approximately 1300 feet (400 m). The assumption of train length and capacity was based on an iterative process between the preliminary ridership forecasts and the conceptual operating plan.



## 2.3 CAPITAL COST ASSUMPTIONS

The capital costs have been categorized into discrete cost elements. In general, the capital costs were estimated by determining the appropriate unit costs for the identified cost elements and the cost element quantities from HSR alignment plan and profile drawings. Each cost element is defined below along with the methods and assumptions applied in each case.

### Alignment Costs

#### Track and Guideway Items

*HSR Track/Guideway:* for steel rail systems (VHS), this includes ballast, subballast rails, ties, fasteners, and special trackwork (turnouts, sidings, etc.). For Maglev systems, this consists of the guideway beams including glide surfaces, guidance rails, and stator packs (the long stator windings are included as a part of the propulsion system). The track required in the maintenance and service facilities, as well as the at-grade or elevated reinforced concrete substructures/foundation guideway costs, including switches, within maintenance and service facilities, are included with the cost of the those facilities.

Track/guideway unit costs were applied per unit length of alignment. For the rail technologies, separate unit costs were applied to account for lengths of ballasted track section and direct fixation. Separate unit costs were applied to account for Maglev at-grade and elevated guideway construction. Special trackwork costs were estimated based on the length of the segment and the need for special track/guideway features, such as turnouts, crossovers, etc. Special trackwork costs were estimated at 15% of total track/guideway costs.

#### Earthwork and Related Items

Included in the detailed categories below are all the earthwork elements and other items related to site development.

*Site Preparation:* the costs for “clearing and grubbing” which cover the removal of unsuitable surface debris, and removal of vegetation. This also includes the cost of “grading” which is the movement of dirt around the site to prepare the surface for construction. Site preparation also includes work done to make the site usable after the demolition of existing structures.

Unit costs for site preparation were applied to the total area required for earthwork

operations along a given segment. The amount of area was based on the earthwork volume calculations.

*Earthwork:* the general category of “earthwork” is made up of four constituent activities: excavation, embankment, spoil, and borrow. Earthwork incidental to the construction of a structure, such as the excavation for a bridge foundation, would not be included here — that cost is a part of the structural estimates.

Unit costs of earthwork were applied to the total volume of earthwork required along a given segment. A digital terrain model was used to calculate the earthwork volumes based on the profile of each segment.

*Landscaping:* for areas alongside the tracks/guideways within the HSR right-of-way. Plantings in station areas to be included under passenger stations. The landscaping along the route includes the seeding of cut slopes and embankments.

*Fencing:* a security chain link fence 8 feet (2.5 meters) in height along the right-of-way. All at-grade sections, cut & fill sections, tunnel portals, and maintenance areas will be fully fenced. A unit cost for fencing was applied per length of alignment.

*Drainage Facilities:* includes culverts and other structures needed for track/guideway and cross drainage purposes only, including track underdrains if needed. This does not include bridges that may handle drainage in addition to their primary purpose. The cost of drainage facilities was estimated at five percent of the cost of earthwork for each segment.



### **Structures, Tunnels and Walls**

Structures are defined as those elements that require structural engineering for design, and fall into the categories below. Buildings (such as passenger terminals and maintenance facilities) are not included under structures but are in other elements.

Viaducts and Bridges: costs for prestressed reinforced concrete aerial structures include the abutment (for a bridge or viaduct) as well as the bridge itself. Included in the cost of that bridge would be the excavation for the abutment including all wing walls and transition slabs. Also included is all the foundation work, including the earthwork needed to construct the foundations. Included under bridge costs are waterway crossings, which were calculated on a per crossing basis. Viaducts and bridges required for roadway or rail crossings are included in the grade separations element.

It should be noted that in California a similar structural section is expected to be required for both Maglev and rail technologies — since aerial structure design for both are controlled by the same seismic loading combination, accessibility and serviceability requirements. In geographical areas of lower seismicity, other loading combinations (e.g. live load) may control. Under those conditions, the lower live load of Maglev vehicles over rail vehicles may result in a reduction of construction costs for aerial structures. A unit cost was applied per length of aerial structure. Different unit costs were used for standard aerial guideway and special structures requiring spans greater than 120 feet (36.6 m) and height exceeding 30 feet (9.1 m).

HSR Tunnels: tunnel boring machine (TBM) and drill and blast (D&B) tunnels constructed beneath the ground level that only require surface occupation at the openings of the tunnel. The costs for these tunnels for the HSR system in-

clude all structural work, ventilation systems, electrical systems related to tunnel (such as lighting, fans, etc.), special drainage, etc. needed to make the tunnel ready for the railroad. This item does not include the track, signaling or traction power systems. Unit costs were applied per length of single and double track tunnel sections.

Seismic Chambers: an oversized tunnel segment to accommodate track realignment and passage of the train subsequent to a major fault rupture event where large displacement is expected.

Retaining Walls: used to support embankments and retained fill along cut sections (retaining walls that are a part of abutments for bridges are included in the bridge costs).

Intrusion Barriers: structural walls (including foundations) required to prevent incursion of vehicles from one area to another. Generally, they are included whenever the HSR track/guideway is at-grade and adjacent to existing freight railroad operations.

Sound Walls: walls used only for sound mitigation, including all foundations and appurtenances needed for their support. Sound walls were included in segments where land use densities warranted their use. For a given segment, the amount of sound wall required was based on the percentage of developed land uses along that segment. This sound mitigation cost was estimated separately from and in addition to the environmental mitigation cost.

### **Grade Separations**

Bridges and Undercrossings: highway and railroad overcrossings/undercrossings of the HSR system. All crossings with other transportation facilities must be grade separated from the HSR system. The unit costs applied for these grade separations include all of the cost elements necessary to complete the construction of the grade separations, such as earthwork, traffic handling, drainage, etc. The number of existing crossings (roadway and rail) per segment was quantified per USGS line graph information, field reconnaissance and other mapping sources according to type (at-grade, under or over) and size (primary, secondary and minor roadways). Judgements were made regarding the proposed crossing type, including undercrossings for farm equipment in agricultural areas and the option of closure for minor roadways, and costs were calculated on a per crossing basis. In the San Francisco Bay Area, extensive field surveys were used to determine a more precise quantification and classification of crossings.

## **Building Items**

*Passenger Stations:* platforms, circulation, lighting, security measures and all auxiliary spaces including intermodal connection areas. Spaces are provided within the station for ticket sales, passenger information, station administration, baggage handling, and a reasonable amount of commercial space for newsstands, restaurants, etc. Different station facility unit costs were applied to four separate station classifications: terminal, urban, suburban and rural. The different unit costs account for differences in station size, configuration and general location. These costs are assumed to be a rough average, since station costs are expected to vary widely by location.

*Site Development & Parking:* the paving, parking structures and landscaping of the site around the passenger station building. Also included is the provision of street and highway modifications necessary to provide access to the site. Different site development unit costs were also applied to the four station classifications: terminal, urban, suburban and rural.

## **Rail and Utility Relocation**

*Railroad Relocation:* The cost of track relocations (temporary or permanent) required to place HSR track/guideway into existing rail corridors, including all construction work needed to relocate the railroad, including earthwork, trackwork, etc. A unit cost was applied to the length of alignment requiring relocation.

*Utility Relocation:* the cost of major utility relocations that must be done before constructing the facilities, such as: overhead power lines, pipelines, and underground ductbanks. Different unit costs were applied to the total length of alignment based on the intensity of land use development along the alignment.

## **Right-of-Way Items**

The total cost associated with the purchase of land and/or easement rights for the HSR system. Includes relocation assistance and demolition costs. Property values and acquisition costs can range from quite modest in undeveloped areas to quite significant in areas where high-value commercial properties near stations are needed. In some cases, the cost of acquisition services may equal or exceed the cost of the property itself. These costs include those for title searches, appraisals, legal fees, title insurance, surveys, and various other processes.

The cost estimates assume that a minimum right of way width of fifty feet (15.2 m) is necessary throughout the length of each segment. Even when the alignment is primarily within existing rail rights of way, costs are estimated to account for the purchase and or lease agreements necessary for operation in these corridors. Wider right of way sections are necessary in mountainous areas where large cut and fill slopes are required. Different right of way unit costs were applied according to the density of the surrounding land uses as determined from the satellite thematic imagery.

Three general parameters were followed: (1) a minimum right of way corridor of 50 feet (15.2 m) has been assumed in congested corridors; (2) a 100 foot (30.4 m) corridor has been assumed in less developed areas to allow for drainage, future expansion and maintenance needs; and (3) a wider corridor was assumed in variable terrain to allow for cut and fill slopes.

## **Environmental Impact Mitigation**

The total cost associated with mitigation of environmental impacts such as wetland replacement, parkland mitigation and biological resource/habitat replacement. Noise mitigation with sound walls and right of way impact and relocation mitigation are estimated separately as defined above.

The total cost of environmental mitigation was estimated to be three percent of the line construction costs (i.e. track, earthwork, structures, etc.) for each segment, based on other recently implemented transportation corridors in California. The environmental mitigation cost for a Maglev system is anticipated to be the same as for a VHS system.



## **Systems Elements**

### **Signaling and Communications Items**

Signaling: these costs cover the cost of wayside, on-board and central control software and hardware for the overall signaling system. The unit costs are applied per length of track/guideway. The VHS technologies operate either on the basis of moving block technology with automatic train protection (ATP) or automatic train control (ATC) and automatic train operation (ATO).

Communications: includes a high capacity fiber optic backbone with full redundancy, which is key for the operation of the Supervisory Control and Data Acquisition (SCADA) and reliable ATC systems. The communication system will be used for operations, maintenance and emergencies, phone and fax capabilities (en-route), closed circuit television, public information systems, public address systems, and other monitoring and detection devices needed for a safe and efficient operating system. The unit costs are applied per length of track/guideway.

Wayside Protection Systems: includes systems/equipment to monitor and/or detect obstacles which may be placed or fall onto the track/guideway, intrusion, flooding, wind, seismic activity and equipment failures (broken rails, hot axles, dragging equipment, etc.). The unit costs are applied per length of track/guideway.

### **Electrification Items**

Traction Power Supply: the entire cost of the substations, including site preparation, foundations, cable trenches, fencing, electrical equipment, etc. The unit costs are applied per unit length of track/guideway. It does not include the cost of transmission lines from the local utility source to the substations. Those are included in the energy costs, a part of the operating and maintenance costs.

Traction Power Distribution: for VHS systems, this includes the catenary poles and foundations, the catenary wires and supports, tensioning devices, power feeders and returns, transformers and other appurtenances. For Maglev systems it includes the power transmission cables and control equipment along the guideway as well as the 3-phase longstator cable windings (mounted in the stator packs on the underside of the guideway). The unit costs are applied per unit length of track/guideway.

### **Vehicle Costs**

These are costs for trainsets (locomotives and coaches). A 600-650 passenger trainset is assumed based on an iterative process between the preliminary ridership forecasts and the conceptual operating plan. Vehicle costs include an inventory of spare parts needed for regular maintenance. The costs are based on recent research with European manufacturers of HSR and Maglev equipment and previous HSR experience. These costs will be updated as additional information becomes available from other equipment manufacturers. Based on the assumed conceptual operating plan and a 10% spare ratio, 38 trainsets and 36 trainsets were assumed for the cost estimates for VHS and Maglev, respectively.

### **Support Facility Costs**

Train Maintenance Facilities and Yards: the building and equipment needed for maintenance of the rolling stock. In addition to the heavy repair facility and its equipment are car washers, special cleaning platforms, other equipment that might normally be located outside in the adjacent yard areas, and the tracks and other facilities for storing the trains in preparation for revenue service. Included also are allowances for the electrification, signaling needed for operations, and such services as water, electricity, fire water, communications, and sewers.

Maintenance-of-Way Facilities & Equipment: the buildings and storage tracks needed to house the equipment and materials to maintain all the non-rolling stock elements of the system, including track/guideway, electrical, signaling and all civil facilities. Also included is all the mobile equipment needed to support the maintenance of way activities. These costs will be included in the single allowance for Support Facilities.

### **Program Implementation Costs**

Costs for these elements are computed as a percentage of the total of construction and procurements costs. The percentages are intended to represent the average overall

cost of these implementation items, based on implementation of rail transit and other related improvement projects throughout the state. The percentages are predicated on a Design-Build or Design Build Operate and Maintain procurement approach and would be significantly higher using a traditional procurement approach. These costs would be divided between the owner and the contractor in this procurement approach and are noted accordingly.

*Preliminary Engineering and Environmental Review:* Preliminary engineering design to approximately a 35% level. This will include geotechnical investigations, land surveying and mapping, engineering, architecture, landscape architecture, traffic engineering, right-of-way engineering, utilities investigations, operational analysis, maintenance facility layout, preparation of preliminary plans and profiles, and analyses in all necessary technical disciplines, and various other technical studies and support of the draft environmental document. The environmental review would entail all studies and analyses necessary to complete both federal and state required environmental documents. (Owner - 2.5%)

*Program & Design Management:* for the overall management and administration of the project. Included were the program manager's office, contract management and administration, project control including both cost and schedule, general administration, computer support, quality assurance, configuration management, system safety, publications, public relations, support of the bidding process, agency liaison, community information and involvement and legal support. (Owner - 5.0%)

*Final Design:* final design and preparation of construction and procurement documents for all facilities and systems. This will include geotechnical investigations, land surveying and mapping, engineering, architecture, landscape architecture, traffic engineering, right-of-way engineering, utilities engineering, operational plans, maintenance facility design preparation of plans and specifications in all necessary technical disciplines, permit applications, and various other technical studies and support of the final design process. Design support during construction, including shop drawing review is also included in this item. (Contractor - 5.0%)

*Construction & Procurement Management:* all management of construction and procurement work after contracts are awarded to contractors or suppliers. This will include on-site inspection in both factory and field, quality control, mitigation monitoring, con-

tract administration and acceptance inspection. (Owner – 1.0%; Contractor – 4.0%)

*Agency Costs:* the costs of maintaining the owner's organization during the entire program, whether that owner is a franchisee or a government agency. (Owner - 1.0%)

*Force Account Costs:* the services of other organizations or agencies of local, state or federal government that may be required to support the project. (Owner - 1.0%)

*Risk Management:* owner supplied insurance or any other allowances decided to be applied for the management of risk to the owner. (Owner - 6.0%)

*Testing & Pre-Revenue Operations:* the costs of pre-revenue testing, acceptance testing, safety certification and training related to start-up of the system for revenue service. These costs would be included in the DBOM contract.

## **Contingencies**

A contingency is added as a percentage of overall project costs — based on past experience for projects in early stages of definition. Contingencies should not be considered as potential savings. They are an allowance added to a basic estimate to account for items and conditions that cannot be realistically anticipated at the time of the estimate. The contingency amount is expected to be needed as the project matures. The contingency is estimated at 25% of the total of construction costs.

## **Unit Costs**

Unit costs were developed for each cost element described above. The unit costs are presented by cost element in Appendix B.





## 2.4 BASELINE CONCEPTUAL

### OPERATING/SERVICE PLAN

In the previous study performed for the High-Speed Rail Commission, conceptual operating plans were developed in conjunction with high-speed rail ridership forecasts, reflecting service requirements in the San Diego, Los Angeles, San Francisco Bay Area, and Sacramento corridors. This operating plan served as the starting point or *Baseline* for the operating plan refinements carried out in this study. The operating plan assumes trains with a capacity of 600 to 650 passengers operating with at least a 65 percent occupancy rate. The assumption of transit capacity was based on an iterative process comparing preliminary ridership forecasts with conceptual operating assumptions regarding frequency of daily service throughout the proposed system. The average 65% load factor represents a conservative yet reasonable assumption allowing for growth and peaking of demand throughout the service period. No formal dispatch/operating models or simulations were applied to develop this conceptual operating plan.

The basic service pattern would be between 6:00 a.m. and 8:00 p.m. for most trains between Los Angeles to San Francisco with some trains starting or finishing trips beyond these hours. To augment the basic service, trains are added in the peak periods, and some trains in the basic pattern make extra stops. Extra express and

suburban-express trains are inserted into gaps in the basic schedule during the peaks. The extra suburban-express stops are made to serve residents of suburban communities who have a destination at the far end of the route. For example, an early train from Los Angeles that stops in Burbank serves a rider who normally works in Los Angeles, but has a business meeting in San Francisco that day. In the evening, some of the express trains destined for Los Angeles also stop in the suburban Los Angeles area to deposit such a rider close to home. A similar pattern of extra stops occurs on the north end of the route around San Francisco.

For statewide intercity service, fifty-two weekday trains in each direction were assumed in the *Baseline* conceptual operating scenario for Year 2015 service. The intercity trains are comprised of four service categories:

- ◆ Express (20 trains/day) - Trains running from either Sacramento, San Jose or San Francisco to Los Angeles and San Diego without intermediate stops.
- ◆ Semi-Express (12 trains/day) - Trains running between similar endpoints as the express, with intermediate stops at major Central Valley cities such as Modesto, Fresno and Bakersfield.
- ◆ Suburban-Express (8 trains/day) - Trains running "local " during either the beginning or the end (LA or Bay Area) of the trip while running express through the intermediate points.
- ◆ Local (12 trains/day) - Trains stopping at all intermediate stops with potential for skipping stops to improve service depending on demand.

The *Baseline* conceptual service plan, which was developed by the Commission to account for a variety of routing combinations and technologies, is included in Appendix C.

## 2.5 OPERATING AND MAINTENANCE

### (O&M) COST ESTIMATES

O&M totals are derived differently than capital costs. Unlike the material take-offs from preliminary plans and pricing of each element, O&M costs result from the development of conceptual staffing plans designed to respond to operating plan requirements. The largest O&M cost component is labor, which is dependent on train number and schedule, and other service-related factors typically not fully defined at this preliminary stage. For this reason, the O&M costs are somewhat less predictable than capital costs. The sum of all train operating and maintenance costs is shown on a per-train-mile and per-train-kilometer basis in *Exhibit 2-11*.

The O&M costs are on a seat-mile (-kilometer) basis to permit factoring over a wide range of service plans. The maintenance-of-way costs are based on track type and length and facilities to be constructed.

**EXHIBIT 2-11**  
**OPERATIONS AND MAINTENANCE UNIT COST COMPONENTS**

Item	VHS Technology		Maglev Technology	
	\$ per train-mile	\$ per train-kilometer	\$ per train-mile	\$ per train-kilometer
Train Operations	\$ 6.08	\$ 3.78	\$ 6.08	\$ 3.78
Equipment Maintenance	7.13	4.43	6.42	3.99
Station Services	0.50	0.31	0.50	0.31
Marketing and Reservations	1.28	0.80	1.28	0.80
Insurance	1.22	0.76	1.22	0.76
General Support	0.88	0.55	0.88	0.55
Maintenance of Way	2.61	1.62	2.35	1.46
<b>Subtotal - Non Power</b>	<b>\$19.70</b>	<b>\$12.25</b>	<b>\$18.73</b>	<b>\$11.65</b>
Power	2.99	1.85	3.43	2.13
<b>Total</b>	<b>\$22.69</b>	<b>\$14.10</b>	<b>\$22.16</b>	<b>\$13.78</b>

### Non-Power Unit Cost Components

The main quantity inputs to the cost model to develop the train operating and maintenance (O&M) costs include:

- ◆ Number of weekday and weekend trains operating along a given corridor
- ◆ Type of service (express, local, etc.)
- ◆ Length of each route alternative

To obtain the annual train operations costs, unit rates on a per train-mile (-kilometer) basis are estimated for certain operating categories and applied to the quantity estimates. These unit rates utilize Amtrak Northeast Corridor Metroliner experience in order to reflect United States labor rates, and include labor, supplies and insurance related to train operations.

Certain other non-direct costs related to the provision of service which tend not to vary strictly on the basis of train-miles (-kilometers) are developed using experience from a variety of sources, including Amtrak, other transportation companies, and previous studies, which included detailed analysis of these costs. Costs in this category, generally considered "long-term avoidable costs" include marketing, reservations, station services and general support. These costs are part of any commercial transportation activity, but do not fluctuate on a short-term basis according to the number of trains being operated as does, for instance, on-board labor or energy costs. They should be included, however, in order to form a complete analysis of the cost of operation. At this preliminary stage, unit rates on a cost per train-mile basis were developed for these indirect costs and used for estimation.



Costs for maintenance of way and structures (including power systems and signaling) are based on a detailed analysis performed in connection with the Texas TGV project in the early 1990's. Maintenance of way includes maintenance and progressive replacement costs for track and all permanent structures, including bridges, tunnels and power distribution systems. Maintenance of equipment figures are based on Amtrak's experience with 125 mph (200 km/h) Metroliner operations and will be assigned on the basis of train-miles. Maintenance of equipment includes all running maintenance and progressive overhaul costs for rolling stock (cars and locomotives).

### **Power**

Power consumption varies according to technology, route, speed, number of stops, and grades. The performance model groups trains into the three service categories: local, semi-express, and express. Average power consumption rates were applied to each segment of the corridor according to technology group and terrain (grades), based on operating simulations prepared by DE Consult as part of the Los Angeles to Bakersfield Preliminary Engineering Feasibility Study. Unit energy costs, which also vary according to train-miles (-kilometers), were derived by dividing the figures for energy consumption computed for each train type by the length of the route, then multiplying by an assumed electric power rate.

Power costs may include a connection charge and maximum demand charges, which can be a significant part of the bill. The rate per kilowatt-hours may be applied in several steps with the rate decreasing with increased consumption of kilowatt-hour. To account for these factors the average unit cost rate for electrical power used in this analysis is assumed to be \$0.11 per kilowatt-hour for both technology groups. This analysis provided power usage rates of \$2.99 per train-mile for VHS technology and \$3.43 per train-mile for Maglev technology.

## 2.6 TRAVEL TIME ESTIMATES

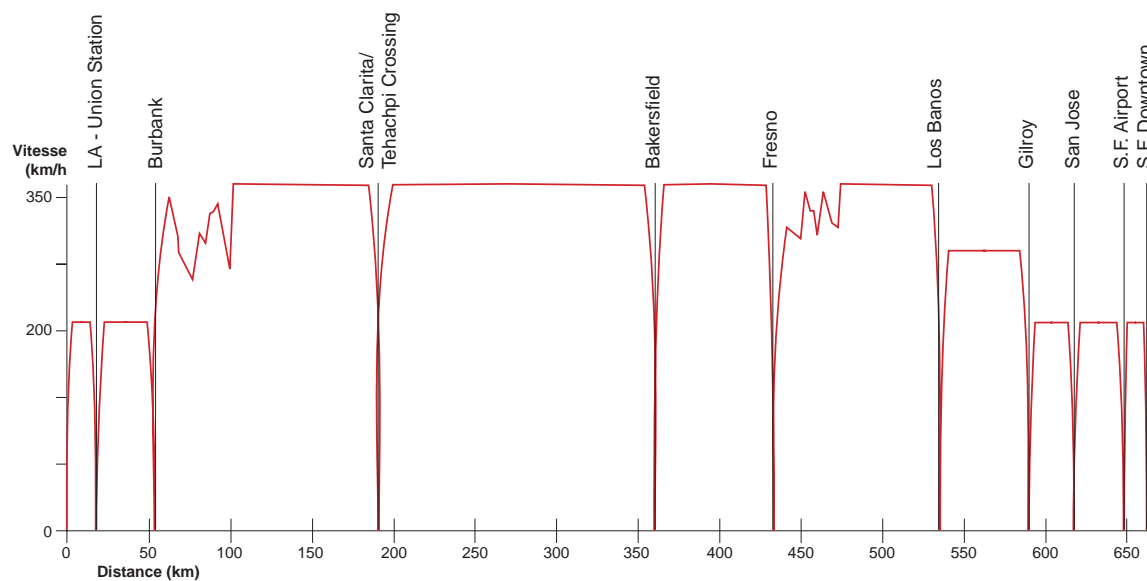
Travel times were estimated for each of the alternative corridors based on alignment and train performance characteristics. Specifically, the travel time estimates account for acceleration and deceleration capabilities of each technology and the ability of each technology to maintain passenger comfort criteria through horizontal and vertical curves. Travel times were calculated for each segment based on the specific geometry and top speed assumptions. Speed degradation on sustained vertical grades was estimated based on simulations to verify and validate the results of the travel time estimates.

The VHS travel time estimates were verified by GEC Alsthom (the firm manufacturing the French TGV trainsets) using a train performance model which accounts for the train's capabilities on sustained grades. An example speed versus distance chart is shown in *Exhibit 2-12*. Maglev travel times were devel-

oped from simulations created by DE Consult (the engineering support firm for Deutsche Bahn AG in Germany) for the Los Angeles to Bakersfield Preliminary Engineering Feasibility Study, 1994.

Travel times were estimated for both technologies for both local and express service. For dwell times at intermediate stations, two minutes per station stop was assumed. All train running times include a six-percent "schedule recovery time" based on European HSR practice.

**EXHIBIT 2-12**  
**EXAMPLE TRAVEL TIME SIMULATION - SPEED VERSUS DISTANCE GRAPH**



Source: GEC Alsthom Transport, 1995



EXHIBIT 2-13  
AVERAGE SPEEDS - EXPRESS VHS TECHNOLOGY

### Speeds

Operating speeds were determined on a segment by segment basis for each of the alternative corridors considered. The operating speeds were based on the design speeds and criteria presented earlier in this chapter with consideration of the physical constraints along each specific segment. Because of the extent of existing development and limited availability of right of way, the HSR speeds through developed urban areas are constrained by the geometry (curve radii) of the existing transportation corridor that the HSR alignment follows. Mountainous terrain also constrains the operating speeds, due to the power loss on sustained climbing grades. In contrast, the flatter rural areas of the Central Valley allow for the full speed capabilities of the train technology considered. Exhibit 2-13 illustrates the operating speed assumptions for express (end-to-end) service on the Baseline corridor.





## 2.7 COMPATIBILITY ISSUES

The technology choice will affect the type of service integration permitted by the new network. The use of Maglev technology creates a unique system of infrastructure and passenger carrying equipment. Existing conventional railroad equipment cannot use this infrastructure so efforts to develop seamless transportation opportunities would concentrate on convenient and easy transfer designs to effectuate a smooth transfer of passengers from one mode to another. A Maglev system can also provide different types of services to meet a range of market needs along the route it traverses.

Using a steel-wheel, steel-rail technology (VHS) may seem to be more easily integrated with conventional passenger and even freight railroad services, however, the wide difference of operating speeds, the lower dependability/reliability of freight traffic and the design requirements for rolling stock used in mixed traffic preclude shared use of high-speed trackage with incompatible services (see detailed discussion below). Again, for steel-wheel, steel rail (VHS) high-speed services, efforts to develop seamless transportation opportunities with incompatible services will concentrate on convenient and easy transfer designs to effectuate a smooth transfer of passengers from one mode to another. A steel-wheel, steel-rail system can also provide for different types of services that meet a range of market needs along its route.

### FRA Safety Rules

Currently the Federal Railroad Administration is in the midst of a rule making that will affect the design of passenger rail rolling stock in the United States. This rule making will also have an impact on the design of high-speed rail trainsets (passenger cars and locomotives or power cars). The key issue for design of an integrated passenger rail system that includes high-speed segments is the impact these FRA requirements have on the “mixing of traffic”. In this case “mixed traffic” means that conventional passenger equipment, high-speed equipment and freight railroad equipment would be operated on the same set of railroad tracks.

### Mixed Traffic

Mixed traffic is not a new concept if a steel-wheel, steel-rail technology is chosen. Mixed freight and conventional passenger trains are operating everyday throughout the United States on the same railroad segments. On the four-track Northeast Corridor main line for instance, Amtrak Metroliners, slower Northeast Direct trains, local and regional commuter trains and freight trains are routinely operated on the same rail rights-of-way with different track assignments. On European and Asian railroads, conventional railroad

traffic in the congested areas near major cities also share the right-of-way with high-speed trains.

In the United States, the issue becomes complicated, however, when the equipment to be operated on the same segments is constructed to different structural design standards. One key FRA requirement is the actual “buff strength” of railroad rolling stock. This is the amount of force that can be applied to the end of a trainset (passenger cars and locomotives or power units) without causing the cars or locomotives to crumple. A high buff strength requirement (a “crash-worthiness” standard focused on accident survival) protects the passengers and railroad employees inside the train in the event of a collision.

In Europe and Asia where high-speed rail operates with an excellent safety record, rolling stock is manufactured to different tolerances than required for rolling stock operated on United States railroads regulated by the Federal Railroad Administration (FRA). These European and Asian passenger and freight trains have been designed for power, speed and safety, but their safety standards focus on accident avoidance rather than accident survival. These lighter trains do not meet current FRA buff strength requirements.

All American railroad equipment designed to operate with heavy freight equipment in mixed traffic has been designed to the same buff strength tolerances. Asian and European high-speed equipment is lighter and falls far short of these “buff strength” requirements.

It is in this area of very different design specifications that the potential problem with mixed traffic arises. American railroad rolling stock adheres to the high strength requirements of the FRA, because of this common design requirement freight and passenger rolling stock can be operated



on the same railroad. The FRA, however, has serious concerns about permitting rolling stock with lower strength and different design criteria from operating in mixed traffic way. The key issue is simply that, in a collision between the higher strength rolling stock and the lower strength rolling stock, a serious safety hazard may result.

In the US, rolling stock being manufactured for the new Northeast Corridor high-speed service between Washington and Boston will meet these “buff strength” standards but will have maximum speeds of just 150 miles per hour. Mixed traffic was deemed non-negotiable on the Northeast Corridor so the rolling stock acquired by Amtrak meets American standards by adopting the interior design and comfort standards of European high-speed trains but placing them on the heavier and stronger American type passenger car designs. These trains will meet the speed design requirements sought by Amtrak for 150 mile per hour running, but will not be able to operate efficiently at higher speeds.

On the proposed Florida Overland Express (FOX) high-speed rail project in Florida, a different approach was taken. In that case, 200mph high-speed service was desired and European rolling stock was specified. The proposed FOX rolling stock was to be based on European designs and on an operating plan that eliminated any mixed traffic operation. The FOX project would have been totally separated from any other railroad operation and would not permit any American style rolling stock to share any track of the new high-speed network. The FRA was asked to make a “rule of particular applicability” to permit non-compliant rolling stock to be used. The FRA has never made the requested ruling, and, since the project has been cancelled, the issue has been set aside.

This issue is important. The separation of the high-speed rail lines and elimination of the possibility of mixed traffic imposes significant right-of-way costs on the California high-speed rail project, particularly as the line penetrates dense urban areas such as the Bay Area in Northern California and the Los Angeles basin in Southern California. If mixed traffic options could be considered, it would permit alignment and design options that would be less costly than the construction of new separated rights-of-way to enter downtown Los Angeles and San Francisco. If mixed traffic options are not permitted, new separate high-speed infrastructure must be constructed to reach the proposed terminal sites.

### **Other Considerations**

These rolling stock design constraints require consideration of other solutions to the dilemma presented by the inability to mix traffic.

### **Remote Terminals**

This service design option would keep the high-speed line outside of the dense urban areas. Improved conventional passenger train operations would allow passengers to transfer from high-speed trains to conventional trains for the last portions of their trips into terminals in major urban centers. All passengers would need to transfer to use the high-speed segments. This service design compromise has been considered in the corridor evaluation studies and it would cause a degradation of passenger convenience and reduce the attractiveness (and economic results) of the service.

### **Compliant High-Speed Trainsets**

This rolling stock design option would require an equipment structural design that meets current FRA requirements and also provides for the desired “high-speed” operation. This would challenge the passenger railroad manufacturing industry to apply new materials and technology applications to achieve the speeds necessary for high-speed running while meeting American strength requirements. An alternative would be the creation of a high-speed trainset capable of high-speed running with “crash-worthiness” established by a combination of actual buff-strength and the protection of passenger equipment by motive power units at either end of the trainset that are designed to absorb the forces of an accident without transmitting those forces to the passenger equipment.

The rolling stock manufacturing industry has not moved significantly in this direction. However, the new rolling stock for the Acela service on the Northeast Corridor does

show some evidence of their willingness to attempt to meet this design goal and these rolling stock design options may be possible to accomplish in the timeframe of the California High Speed Project.

### **Permitting Non-Compliant Trains in Mixed Traffic**

Lastly, there could be a proposal to change American requirements to permit mixed traffic at reduced speeds and relying on crash avoidance and train control technologies to assure fail-safe operations. This would require that the FRA adopt a different approach on these matters. Considering the history of federal concerns and actions, this option may take years to enact and would require a focused effort to be initiated soon to achieve the desired changes.

### **HSR Compatibility Assumption**

Practically, it is appropriate to assume that California's high-speed network would penetrate urban areas and provide direct service to major destinations. Until manufacturers step forward with proposals to manufacture trains that both meet FRA design standards and achieve true high-speed running, it is also appropriate to assume that high-speed services will need to be separated without any mixed traffic with conventional passenger or freight railroad rolling stock. This does not, of course, preclude the use of the high-speed infrastructure to provide a "family" of passenger and freight services as long as the rolling stock used is totally compatible and does not create any special safety problems. This assumption was applied to all of the corridors evaluated, except LOSSAN where a different approach was taken as described in Chapter 3.

Due to the proposed speeds, in excess of 150mph, and the buff strength of the rolling stock proposed, a "rule of particular applicability" will still be required for the California HSR system. This rule will address operation and safety issues including speed, control and separation as outlined below.

### **Separation**

The assumption of an isolated infrastructure requires that the new high-speed trackways be built separated from the current railroad tracks either by being on completely new alignments or within existing rail corridors separated vertically or horizontally by distance or by barriers of some kind.

The alignments under study in the Central Valley would separate the new infrastructure on new alignments or adjacent to existing rail facilities. As the proposed alignments, however, enter into major urban areas in Northern and Southern California, alignments will be shared and other solutions are required. The practical assumption, above, requires alignment separation solutions and station arrangements that permit transfers.

### **Horizontal Separation**

Where sufficient right-of-way width is available, the construction of a two-track VHS or Maglev guideway can be designed to be adjacent to an existing conventional railroad alignment. Where a horizontal separation is needed, protection of the trackway will be required. Using barriers and electronic intrusion alarms will provide a level of protection to give effect for the requirement for full access control to protect the high-speed guideway from pedestrians, wildlife, livestock, and vehicles of any type. If the alignments are close, a crash-wall capable of withstanding a derailed train and creating an unbreachable barrier between the trains may be required.

### **Vertical Separation**

Where sufficient right-of-way width is not available for the construction of a two-track guideway, aerial structures will be required. Aerial structures carrying two tracks will simplify the protection of the trackway, however, design and cost issues will be complex. Where aerial construction is required, the design of stations and transfer paths will be extremely important so that passengers can conveniently access the system and move between it and other modes.



## 2.8 POTENTIAL FREIGHT SERVICE

In addition to the mixed traffic based compatibility issues address above, there are other issues associated with the potential operation of freight services with HSR passenger services. Operating freight trains at axle loads approaching conventional U.S. axle loads would compromise HSR operating efficiency, maintenance standards/tolerances and strict safety requirements. Conventional U.S. freight trains also require different track geometry in terms of superelevation. In addition to the substantially higher axle loads required by the conventional railroad freight services (e.g., coal trains), they also require larger clearances due to the size of the cargo (double or piggyback containers). These larger clearances would impact the design of the electrification distribution system, undercrossings and tunnels. For these reasons operation of conventional full-tonnage freight trains is incompatible with HSR in California.

Two other types of freight movement are compatible with California HSR and provide significant growing markets.

### **Small Package/Light Container**

Package/container versions of the high speed passenger vehicles (both VHS and Maglev) can be adapted, without compromising operating capabilities, to handle mail, express parcel, package freight, and other container freight that does not exceed the weight of typical passenger loadings. Examples of this type of freight include overnight small packages and mail, distributed by such entities as Federal Express, United Parcel Service, and the U.S. Postal Service. The equipment used for these services must be completely compatible with the passenger equipment and be capable of safely traveling at the top design speeds of the entire high-speed system.

### **Special Medium-Weight Freight**

High speed (VHS technology) medium weight freight trains with limited axle loads of 19 metric tons<sup>(1)</sup> or less, as opposed to conventional full-tonnage U.S. freight at about 27 metric tons per axle. These freight-only trains would be designed to meet high-speed system safety and design standards but would only operate during nighttime hours at no more than 125 miles per hour. The freight only periods would be scheduled after passenger trains were beyond the area of freight operations and would be coordinated so that they did not interfere with required nighttime maintenance activities. These services can be provided on the system currently being proposed within current parameters of cost and design. Maglev freight trains could carry up to 18 metric tons<sup>(2)</sup> per car on the guideway as planned. The Maglev freight trains with up to 20 cars could be operated at speeds up to 125 mph (200 km/h). By restricting these high speed freight operations to the non-passenger service hours (night time) conflicts with the faster HSR passenger trains can be avoided.

Such trains would be required to operate without having a negative impact on the infrastructure's precise vehicle/guideway/traction power interfaces and design tolerances along the right-of-way or requiring significant additional maintenance. These high-speed medium-weight freight trains could be capable of moving time-sensitive freight, which would be defined by the load-bearing capabilities of the equipment. Examples of this type of freight include time-sensitive containers of electronic equipment and perishable items. In addition, such equipment would have to be designed with very high safety standards and be subject to high level of safety inspection to achieve the same level of safe performance as the passenger equipment.

These medium-weight freight trains could be dispatched after the last passenger train and would need additional separation to assure safe operations. Freight train separation would be consistent with slower speed and heavier operations. Conceptually from four (4) to six (6) freight trains could be operated in each direction nightly (at the top maximum speed of 125 miles per hour), if the trains are fleeted from each end of the corridor and separated safely. Trains would be set up so that their pick-up and drop off work would be staged along the corridor with the first train doing the work at the furthest point with an additional hour of travel time being added for this purpose. The window for freight operations would be limited by the initiation of passenger services in the morning

<sup>1</sup> One metric ton equals 1.102 English tons.

<sup>2</sup> According to Transrapid International, maglev freight trains could carry up to 30 metric tons per car if a special guideway section is used.

and all arrangements necessary for access to the right-of-way by maintenance forces.

Maintenance force access, however, would not preclude freight train operations since maintenance would not take place over the entire corridor but would be confined each night to specific segments. Freight operations could be routed to provide for single track running and reduced speed in work areas to maintain corridor wide nightly operations and provide for high levels of safety.

### Profile Grades

Freight operations could be affected by the alignment chosen for the corridor. If grades are severe, more than three and one half percent (3½%), freight operations by even these special medium weight trains may not be economically feasible due to the required levels of power and the length of the grades. However, both of the compatible HSR freight services outlined above are capable of operating on sustained 3.5% grades. While some speed loss is expected with the freight-only trains, they will be capable of operating efficiently during the nighttime hours. The increased amount of tunneling and associated costs required to provide conventional railroad grades (2% maximum) through the Tehachapi Mountain crossing are significant as shown in *Exhibit 2-14*. At 2% maximum grades the HSR profile is not able to rise above the terrain through many segments requiring lengthy tunnel segments. The significant increase in infrastructure costs due to

lower grades are not offset by the relatively minor power cost savings.

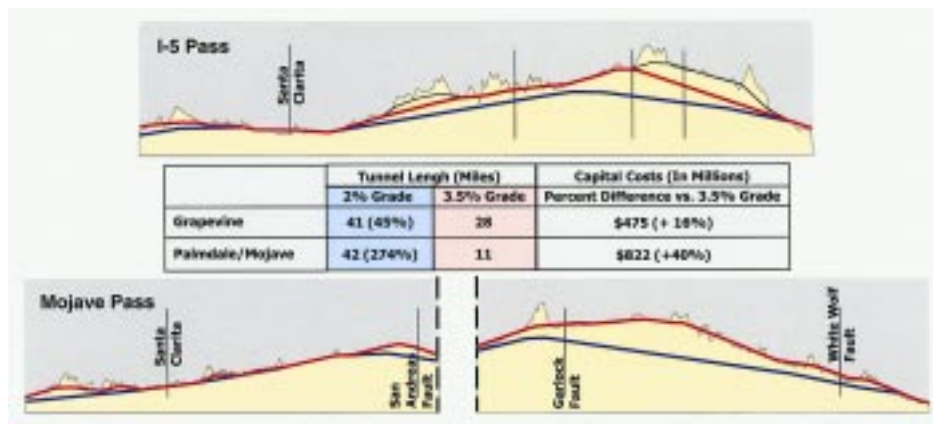
### Freight Infrastructure

Freight services on the high-speed network will require operating arrangements and physical facilities to handle freight at origin and destination points.

For small package and light container services, loading and unloading can be accomplished quickly at passenger stations. Employees would unload and load any material destined for the each station quickly within the dwell times established for passenger trains. This will require interior designs that permit sorting “on the go” and fast means of accepting new packages and releasing packages from the car to the platform. Special destination specific containers may be part of the overall design for this type of service. For these types of freight accommodations will be required at stations for package deliveries and assembly into destination specific containers and disassembly for final delivery.

For heavier freight services, which will be handled by special freight only trains, infrastructure requirements may be more elaborate. If these trains are handled during “freight only” operating windows when no passenger trains are on the network, passenger stations could be used to handle goods. It may be necessary to build special loading and unloading facilities either adjacent to the passenger platforms or at remote sites. These issues are freight service design issues, which need to be incorporated into whatever processes the Authority chooses to advance the freight concepts toward business planning. The Authority has adopted the policy of not budgeting for special freight equipment or infrastructure as part of the initial financial and operating plans.

**EXHIBIT 2-14  
TEHACHAPI CROSSING PROFILES**





# REGIONAL CORRIDOR EVALUATION

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# III - REGIONAL CORRIDOR EVALUATION

This chapter defines the corridors that were considered for high-speed rail service as part of this corridor evaluation study. In some cases, these corridors were considered in previous studies. Many of the alternatives have grown out of regional and local agency input and further consideration by the project team and Authority members and staff. While input was solicited from regional and local agencies during the development and study of these alternatives, further review and input will be necessary as these alternatives are further defined and studied to confirm their acceptability and viability in terms of cost, engineering feasibility and potential impact.

## 3.1 METHODOLOGY

The purpose of this Corridor Evaluation Study is to provide the Authority with a technical basis for recommending an overall HSR network of corridors. Previous studies were limited in the number of alternatives that could be analyzed in certain areas of the State. In addition, other potential corridors and new issues have been identified as regional and local agencies have had more time to consider the recommendations of the previous Commission. To address these issues, further corridor investigations and evaluations were conducted in several areas of the State and compared in the context of updated information on previously studied routes.

These corridor investigations and evaluations required the preparation of alignments, conceptual engineering, capital and operating costs, travel times and environmental analysis. The current analysis used methods consistent with those applied in the previous corridor evaluation studies in order to maximize the utility of the past work. Corridor Evaluation findings have been verified and provided to Authority staff for use in other efforts such as development of the financial plan, ridership and revenue estimates and public outreach.

A comprehensive, yet efficient approach to develop and assess HSR alignments was developed and applied in the previous corridor evaluation studies conducted for the Commission. This approach, which blended Geographic Information System (GIS) and Computer Aided Design and Drafting (CADD) capabilities, was updated in terms of the most recent data sets and applied in this study. Following this approach, HSR alignments are developed in an interactive computer environment using a variety of reference sources including USGS map-

ping, satellite imagery, aerial photography (where available), digital terrain models and constraints mapping (sensitive land uses and habitat, geologic hazards, wetlands, utilities, etc.).

The alignment development process is based on the application of the assumptions and parameters set forth in Chapter 2 combined with the visual depiction of constraints and the quantification of impacts and cost items. Items such as roadway crossings, rivers, environmentally sensitive areas (parklands, wetlands, floodplains, etc.), terrain and earthwork are all identified and tabulated. A detailed list of data sources used in this study is included in Appendix D.

Conceptual plans and profiles were developed for each HSR corridor alternative studied. These plans were used as the basis for preparing construction cost estimates, travel times and the potential environmental constraints/issues for each alternative segment and both VHS for Maglev technologies.

Within each region, the alternative corridors were evaluated on several key criteria: capital cost; travel time; operating cost; constraints/issues; ridership; and revenue. The capital costs, travel times, and operating costs for each alternative were developed according to the assumptions and parameters defined in Chapter 2. Potential constraints (environmental, engineering, operational, right of way, and institutional) were assessed for each alternative. Ridership and revenue data was provided by Charles River Associates.



### 3.2 REGIONAL CORRIDORS STUDIED

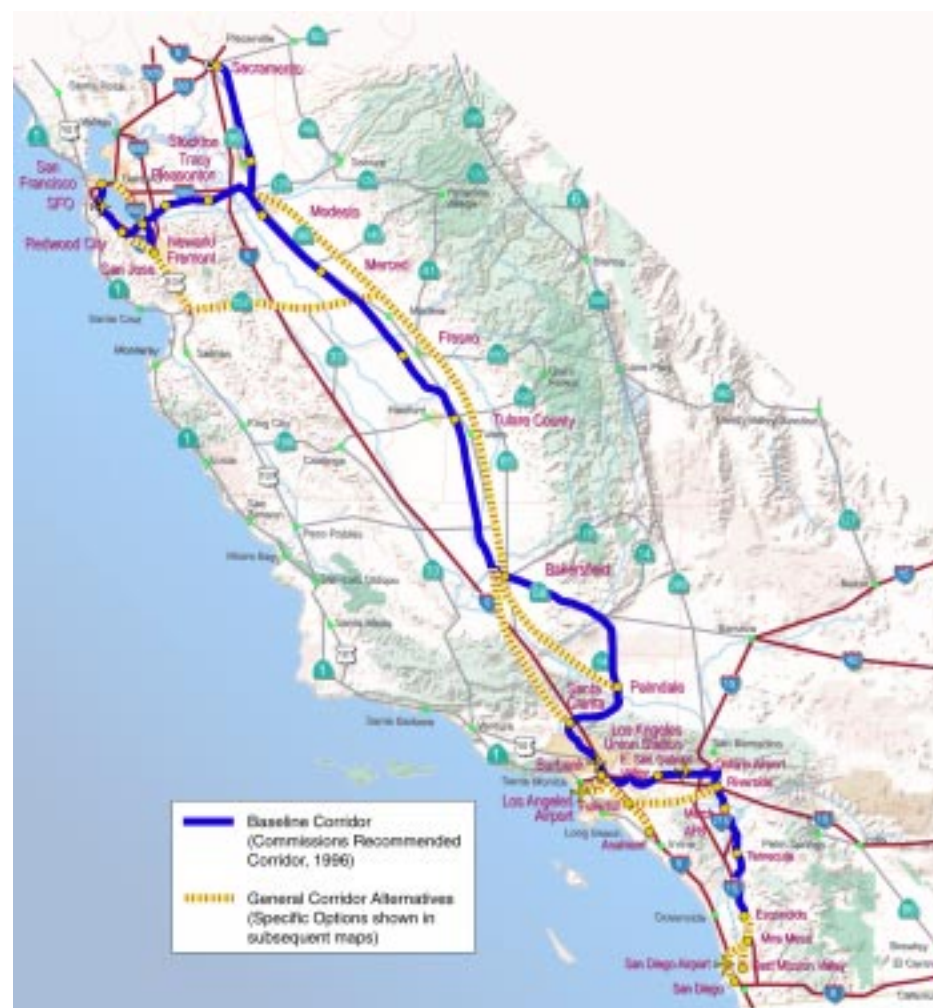
A variety of corridor alternatives were studied in each region throughout the state as shown in *Exhibit 3-1*. The corridor alternatives were studied as discrete segments within the context of a statewide system. Upon completion of the region by region analysis, segments were combined to create several overall statewide HSR system alternatives. All of the regional corridor segment alternatives are defined below and shown on the attached series of graphics along with the Commission's proposed corridor (*Baseline Corridor*), which will serve as the point of comparison for the corridor evaluation studies. The overall statewide HSR system alternatives will be defined in a subsequent section.

For the purposes of comparison, the regional corridor alternative segments were organized into regions as follows: San Diego, Los Angeles, Tehachapi Crossing (Southern Mountain Pass), Central Valley, Sacramento, Bay Area Access (Northern Mountain Pass), and Bay Area.

#### San Diego Area Alternatives

The San Diego Area can be served via two main corridors: the coastal corridor (existing LOSSAN rail corridor) or the inland corridor (I-215 and I-15 highway corridors) from Riverside as shown in *Exhibit 3-2*. These corridors provide three options (downtown, airport and Qualcomm stadium) for the location of the San Diego terminal station. Options for traversing east to west to enter downtown San Diego from Inland corridor are limited. In the previous corridor evaluation work performed for the Commission, both Mission Valley and Penasquitos Canyon were studied as optional routes for approaching downtown San Diego. Both of these routes are currently considered infeasible due to the extent of environmental issues.

EXHIBIT 3-1  
CALIFORNIA CORRIDOR ALTERNATIVE -  
BASELINE WITH ALTERNATIVES



### **Inland Corridor**

For the inland corridor, the options studied for the Authority include crossing over to the coastal corridor either north or south of Miramar Naval Air Station or terminating service in East Mission Valley at Qualcomm Stadium, thus stopping short of the downtown San Diego area. The alternatives are described below and illustrated in *Exhibit 3-3*.

Terminus at QUALCOMM Stadium - From the Temecula area in Riverside County, the HSR alignment would generally follow the I-15 corridor south to Escondido as previously studied by the Commission. South of the Escondido area the alignment would be placed within the I-15 right of way corridor to the maximum extent possible. The alignment would remain in the I-15 corridor to a terminal station in the area of QUALCOMM Stadium integrated, in terms of passenger transfer, with the existing San Diego Trolley station. This alignment would potentially include stations at Escondido, Mira Mesa and QUALCOMM Stadium.

Downtown San Diego - The HSR alignment will follow the same routing as Alternative 1 in the I-15 corridor to the Miramar Naval Air Station. At this point there are two alignment options to the west to reach the existing LOSSAN rail corridor as shown in *Exhibit 3-3*. (1) The alignment would turn west following along the south side of Miramar Road and join the LOSSAN corridor in Rose Canyon. (2) The alignment would proceed south along I-15 to SR-52 and turn west in or along the SR-52 corridor. East of I-805 the alignment would be placed within the right of way SR-52 to the maximum extent possible prior to turning south along the LOSSAN corridor. Both options would follow the LOSSAN corridor south to a terminal in downtown San Diego. This alignment would potentially include stations at Escondido, Mira Mesa and downtown San Diego and/or San Diego International Airport.

### **LOSSAN Corridor**

Incorporating the LOSSAN corridor within the HSR system is a unique case and required approaching it as a separate study. This study is presented in Section 3.4.

**EXHIBIT 3-2  
SAN DIEGO ALTERNATIVES**



**EXHIBIT 3-3  
SAN DIEGO AREA**







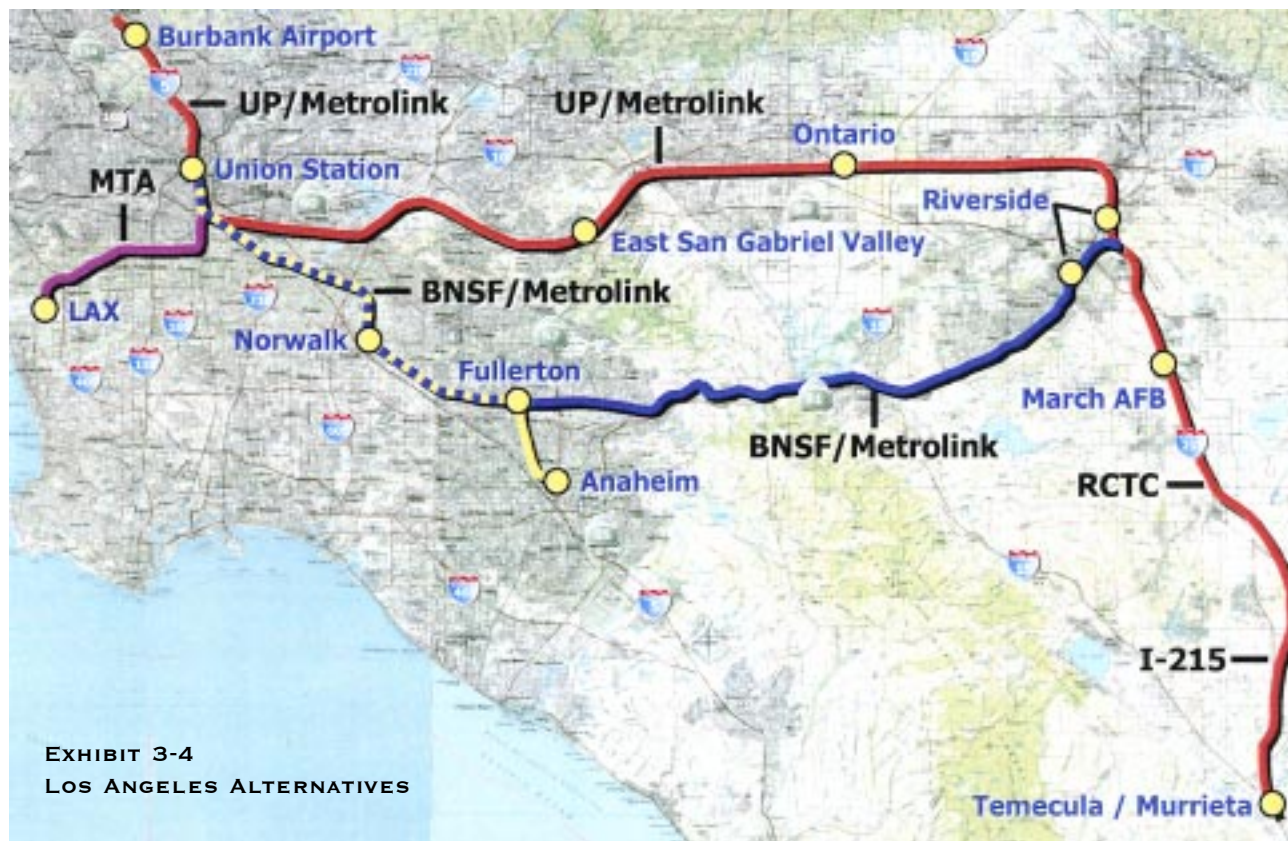
### Los Angeles Area Alternatives

The greater Los Angeles area can be served by a variety of alternative alignments. While these alternatives serve the Los Angeles area, several of them also serve as part of the connection to the San Diego area. These alternatives are presented individually, however, a statewide corridor alignment may utilize more than one of these alternatives to provide service to Southern California. The alternatives are described below and illustrated in *Exhibit 3-4*.

### Inland Empire Alternatives

A variety of alternatives were considered for serving the Inland Empire, but only two alternatives were considered physically and politically viable and were evaluated. Both of the Inland Empire alternatives could serve as either a branch line terminating in Riverside or as part of the through route (inland corridor) to San Diego.

UP/Metrolink Ontario-Riverside (Baseline)- This alignment follows the Baseline Corridor from Los Angeles along the UP/Metrolink corridor to Ontario Airport. From Ontario Airport the alignment continues along the UP line to just east of I-





215 where it turns south through Riverside around the eastern edge of the University of California Riverside campus and joins the existing rail corridor (owned by Riverside County Transportation Commission). The alignment proceeds south generally along the I-215 corridor to Temecula. This alternative is consistent with the findings of the Inland Empire's High Speed Rail Task Force. Potential stations include East San Gabriel Valley, Ontario Airport, Riverside (Highgrove), March Air Force Base, and Temecula.

*SR-91/Metrolink Corridor from Orange County* - This alignment follows the existing Metrolink corridor from Los Angeles to the Fullerton Transportation Center in Orange County. The alignment then proceeds east from Fullerton into Riverside County along the SR-91/BNSF/Metrolink Corridor. In Riverside, the alignment turns south to join the Baseline Corridor and proceeds along the existing rail corridor and I-215 southward as described in the baseline alternative. Potential stations include Fullerton, Riverside (Downtown), March Air Force Base, and Temecula.

### **Orange County Alternatives**

All of the corridor alternatives serving Orange County follow the existing BNSF/Metrolink corridor between Los Angeles and Fullerton. At Fullerton three options were studied. First, extend service east to the Inland Empire as defined in the Inland Empire Alternatives above. Second Extend service south to Anaheim along the existing LOSSAN corridor as a branch line. Third, extend service south to San Diego as a through mainline route along the existing LOSSAN rail corridor (coastal corridor).

*SR-91/Metrolink Corridor* - This alignment follows the existing BNSF/Metrolink corridor from Los Angeles to the Fullerton Transportation Center. Potential stations include Norwalk and Fullerton Transportation Center.

*Orange County Branch Terminus* - This alignment would follow existing Metrolink corridor south from Los Angeles to the Fullerton Transportation Center and then continue proceeding south through Anaheim to the Irvine Transportation Center. This branch line could terminate in Fullerton, Anaheim or even as far south as Irvine. Potential Stations include Norwalk, Fullerton Transportation Center, Ana-

heim and Irvine Transportation Center.

*LOSSAN Corridor* – This alignment would serve Orange County as part of through service to San Diego via the LOSSAN corridor, as defined in Section 3.4

### **Los Angeles to Los Angeles International Airport Alternatives**

This alternative would connect the HSR system with the Los Angeles International Airport (LAX) via a branch line. It is not possible to proceed south from this segment as part of through service to San Diego. Only one option was studied.

*Existing MTA/BNSF Rail Corridor* - This branch alignment would follow an existing Metropolitan Transportation Authority (MTA)/Burlington Northern Santa Fe (BNSF) rail corridor south from Union Station through Los Angeles and then west towards LAX. The alignment passes through the communities of Los Angeles, Vernon and Inglewood. The HSR alignment would serve the airport terminal via a terminal station in Parking Lot C, where passengers would transfer to local airport circulation facilities to reach the airport terminal.



EXHIBIT 3-5  
TEHACHAPI CROSSING ALTERNATIVES



### Tehachapi Crossing Alternatives

Several routes were considered to cross the Tehachapi Mountains north of Los Angeles and join with potential HSR corridors in the Central Valley. These alternatives vary alignments in and around the Bakersfield area to join with each of the Central Valley options. From LA Union Station to the I-5/SR-14 junction, all of the alternatives follow the existing UP/Metrolink corridor and include a potential station at Burbank Airport. The alternatives are described below and illustrated in *Exhibit 3-5*.

*Antelope Valley/Mojave Pass (Baseline Corridor)* – This alignment follows SR-14 through the Southeast edge of Santa Clarita turning to the east in Soledad Canyon and then generally following the UP/Metrolink corridor into Palmdale. The alignment follows the UP rail line and Sierra Highway northward through the Antelope Valley to Mojave. The alignment proceeds to the northwest generally in the SR-58 and BNSF rail corridor through the Tehachapi Mountains into the Central Valley and Bakersfield. In approaching Bakersfield, there are two alternatives to this alignment, either through downtown or along a southern bypass that then serves the suburban area. Potential stations include Santa Clarita, Palmdale, and Bakersfield (Downtown or Suburban).

*Aqueduct Pass* – This alignment proceeds to Palmdale in the same manner as the Antelope Valley/Mojave Pass alignment, however, it turns to the west after the Palmdale station and across the valley to the California aqueduct corridor. This alignment follows the aqueduct corridor through the Antelope Valley, across the Tehachapi Mountains and then up the Central Valley, following the SR-99 north to Bakersfield. Potential stations include Santa Clarita, Palmdale, and Bakersfield (Suburban or Downtown).

*I-5/Grapevine* – This alignment follows the I-5 corridor north through Santa Clarita and the Tehachapi Mountains crossing to the Central Valley. The alignment heads north in the Central Valley generally following the SR-99 corridor into Bakersfield. Potential stations include Santa Clarita and Bakersfield (Suburban or Downtown).

## Central Valley Alternatives

Four alternatives were studied through the Central Valley, each starting in the vicinity of Bakersfield and ending in the vicinity of suburban Stockton. Three of the corridors were studied previously. A new corridor was considered to the east of SR-99. The alternatives are described below and illustrated in *Exhibit 3-6*.

*East of SR-99* – This alignment lies east of and generally parallels the SR-99 from Bakersfield until north of Modesto. Just north of Bakersfield, this alternative briefly follows the UP corridor before turning to the northeast. The corridor resumes northward before the Kern/Tulare County line. After passing to the east of Visalia, the alignment takes a more westerly direction, heading towards the eastern edge of Fresno. This alternative follows Clovis Avenue through the eastern edge of Fresno connecting with Fresno-Yosemite International Airport. After passing Fresno, the corridor runs northwest until joining the BNSF corridor south of Merced. The corridor remains with the BNSF through the remainder of the valley, with the exception of an eastern bypass around the town of Merced.

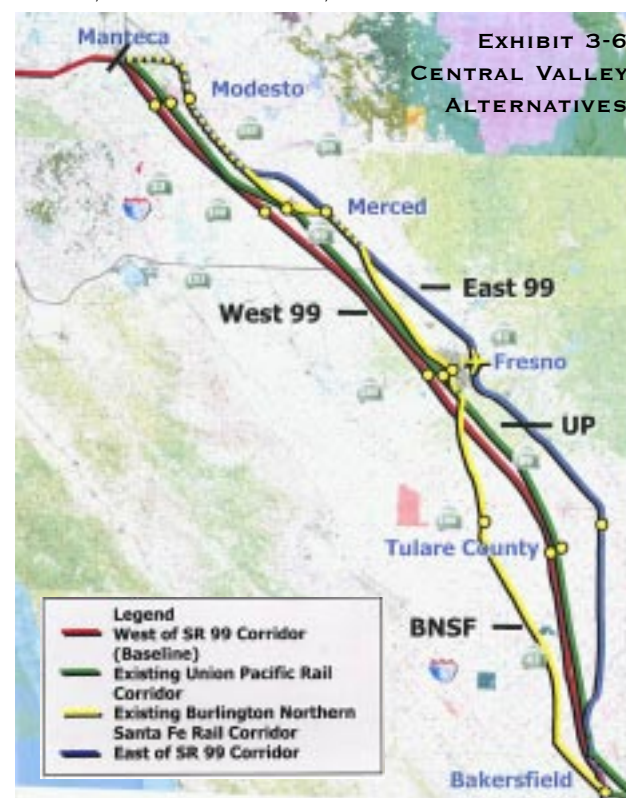
The alignment grew out of local agency and public comment to minimize farmland disruption and better serve the growing areas of the Central Valley Cities as compared to the Baseline Corridor west of SR-99. This corridor was designed to skirt the eastern edge of the major Central Valley cities. Potential stations include Tulare County, Fresno Airport, Suburban Merced, and Suburban Modesto.

*West of SR-99 (Baseline Corridor)* – From Bakersfield to the Fresno/Tulare County line, this corridor follows a new alignment parallel to the SR-99 and at a distance of approximately 1.5 miles to the west. From this point northward the corridor still roughly parallels that of the SR-99 but at a greater distance (4-6 miles). This corridor was designed to skirt just to the west of the major Central Valley cities. Potential stations include Tulare County, Suburban Fresno, Suburban Merced, and Suburban Modesto.

*BNSF Rail Corridor* - This alignment follows the existing Burlington Northern Santa Fe (BNSF) rail corridor through the Central Valley from Bakersfield to suburban Stockton. This corridor lies to the west of SR-99 until reaching Fresno. The corridor passes through Fresno and then remains to the east of SR-99 for the remainder of the valley. There are a number of tight curves along the existing BNSF alignment, many of which occur in congested urban areas. Potential stations include Hanford,

Downtown Fresno, Downtown Merced, and Suburban Modesto.

*UP Rail Corridor* - This alignment follows the existing Union Pacific (UP) rail corridor through the Central Valley from Bakersfield to suburban Stockton. This corridor parallels the SR-99, which passes directly through each of the major cities in the valley. Unlike the BNSF corridor, the UP corridor has fewer speed constraining curves. Potential stations include Tulare County, Downtown Fresno, Downtown Merced, and Downtown Modesto.







### Bay Area Access Alternatives

Two main options were considered for joining the Central Valley alignments with the Bay Area. They are described below and illustrated in *Exhibit 3-7*.

Altamont Pass (Baseline Corridor) – This alignment heads west from the SR-99 corridors just south of Stockton and proceeds over the coastal mountains via the Altamont Pass. The corridor follows the I-580, approaching the bay area from the east. At Newark the alignment branches, with one branch turning south following the existing Mulford Line to a terminus in San

Jose while the other branch could serve either the peninsula and San Francisco or the east bay and Oakland. Potential stations include Tracy, Pleasanton, Newark/Fremont, and San Jose (Diridon Station).

Pacheco Pass - This alignment turns to the west from the SR-99 corridors approximately 25 miles north of Fresno. The corridor crosses the coastal mountains via the Pacheco Pass in the vicinity of SR-152 and the San Luis Reservoir. Near Gilroy the alignment turns north to join the existing Caltrain rail corridor and proceeds to San Jose, approaching the bay area from the south. Potential stations include Los Banos, Gilroy, and San Jose (Diridon Station).



EXHIBIT 3-8  
BAY AREA ALTERNATIVES



### Bay Area Alternatives

Several corridor and termini options were considered in the Bay Area. The area could be served by one or more (in combination) of these alternatives. The alignments are described below and illustrated in *Exhibit 3-8*.

*East Bay* - This alignment follows the existing rail corridor (Mulford Line) north from San Jose towards Oakland. It is compared to the Baseline Corridor on the Peninsula for both of the Bay Area entrances: Pacheco Pass and the Baseline Altamont Pass. The terminal station could be located at either West Oakland along the existing line or at Lake Merritt, which would require a new alignment joining the Mulford Line with the existing Lake Merritt BART station. Potential stations include Newark, Oakland Airport, West Oakland and/or Lake Merritt.

*Peninsula Corridor (Baseline Corridor)* - This alignment follows the existing Caltrain rail corridor northward from San Jose (Pacheco Pass) or Redwood City (Altamont Pass) towards San Francisco. The downtown terminus could be located at the existing Caltrain terminus at 4<sup>th</sup> and Townsend or at the Transbay Terminal, which would require a new alignment from the existing terminus. Potential stations include Redwood City/Palo Alto, San Francisco Airport, and Downtown San Francisco (4<sup>th</sup> and Townsend or the Transbay Terminal).

*Terminus at Interface with Regional Transportation System* - Several options were considered to terminate either alternative at a point prior to the downtown terminus with passengers connecting into regional transportation systems. Other potential termini included SFO, Oakland Airport, San Jose, and Pleasanton depending on the alignment option.





EXHIBIT 3-9  
STOCKTON - SACRAMENTO CORRIDOR

### Stockton - Sacramento Corridor

Alternative corridors between Stockton and Sacramento were not considered in this study. A single alternative for this region was developed in previous corridor evaluation studies. From the Central Valley alignments, the corridor passes east of Stockton along a new alignment. North of Stockton, the corridor follows the existing UP corridor north into Sacramento. This corridor is shown in *Exhibit 3-9* and was assumed in all the statewide systems. Potential stations include Suburban Stockton and Sacramento.

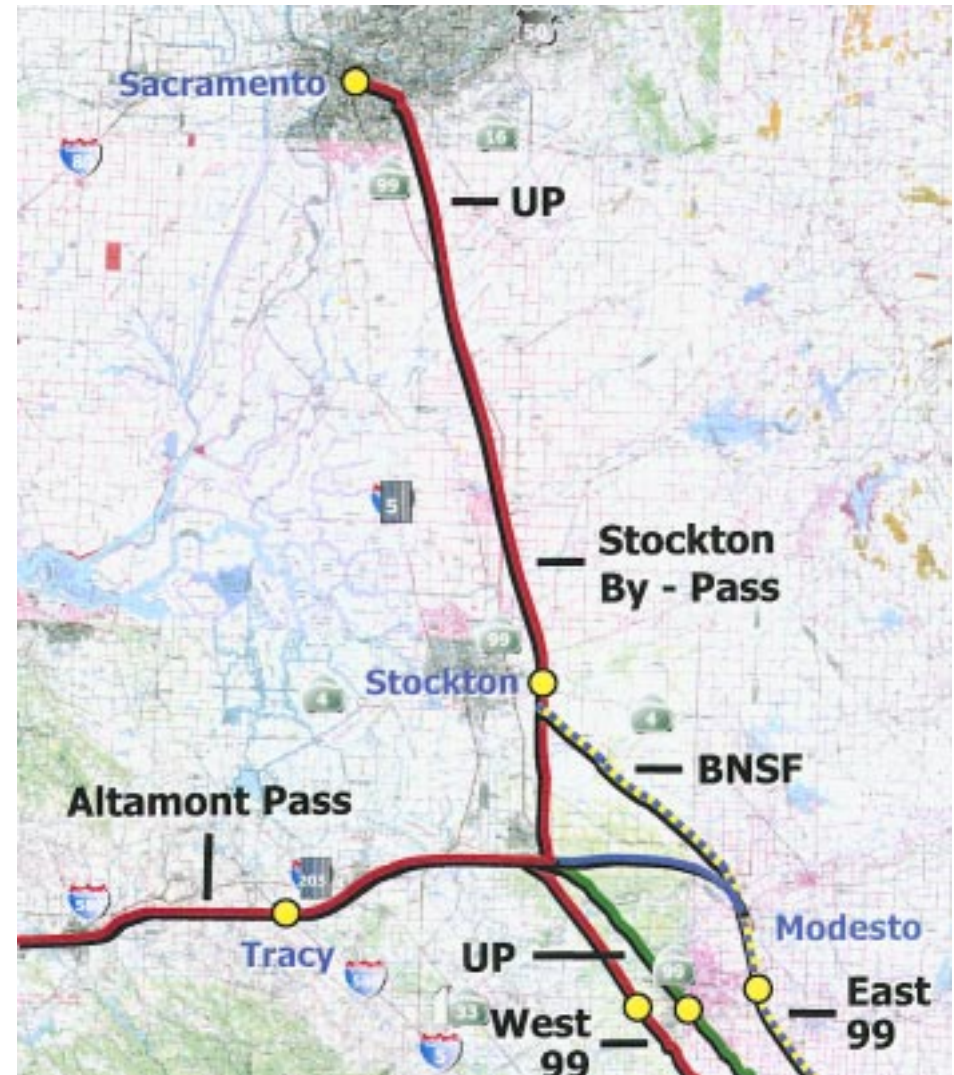






EXHIBIT 3-10  
SAN DIEGO AREA

### 3.3 REGIONAL SEGMENT EVALUATION

The key evaluation factors are presented and discussed for each region below. It is important to note that the cost, travel time and ridership information is presented as it was presented originally to the Authority. A few changes have occurred in the numbers presented since that time (e.g., revised project implementation factors). However, these revisions did not change the relative comparison of the alternatives and are reflected in the overall system evaluation in the next section.

The ridership and revenue estimates were prepared by Charles River Associates and are provided here for reference. For a thorough discussion of the ridership and revenue analysis, refer to the [Ridership and Revenue Final Report](#), December 1999 by Charles River Associates.



	VHS		MAGLEV	
	Miramar Road		Miramar Road	
	DOWNTOWN	AIRPORT	DOWNTOWN	AIRPORT
Capital Cost (\$1999) *	\$1,046		\$1,252	\$1,120
Travel Time (Minutes)				
Express	13		11	9
Length (Miles)	22.0		22.0	19.9
Ridership *	19,99/NA		26,83/NA	26,81/-0.1%
Revenue (\$1997) *	\$688/NA		\$996/NA	\$989/-0.1%
O&M Cost *	\$13.9		\$16.2	\$14.7
	SR-52		SR-52	
	DOWNTOWN	AIRPORT	DOWNTOWN	AIRPORT
Capital Cost (\$1999) *	\$1,303	\$1,184	\$1,523	\$1,396
Travel Time (Minutes)				
Express	14	11	11	9
Length (Miles)	23.8	21.9	23.8	21.9
Ridership *	19,99/NA	19,96/-0.1%	26,83/NA	26,81/-0.1%
Revenue (\$1997) *	\$688/NA	\$687/-0.1%	\$996/NA	\$989/-0.1%
O&M Cost *	\$17.2	\$15.7	\$17.5	\$16.0
	I-15		I-15	
	QUALCOMM		QUALCOMM	
Capital Cost (\$1999) *	\$637		\$717	
Travel Time (Minutes)				
Express	4		4	
Length (Miles)	16.1		16.1	
Ridership *	20,34/+1.8%		27,28/+1.7%	
Revenue (\$1997) *	\$698/+1.4%		\$1,004/+1.5%	
O&M Cost *	\$7.3		\$7.4	

Notes: All Alternatives from Mira Mesa to Terminal Station.  
\* Millions Annually; \$ Millions for Capital Cost

**EXHIBIT 3-11**  
**SAN DIEGO EVALUATION**  
**VHS/MAGLEV**

### San Diego Region

As previously defined, the San Diego region alternatives include the coastal LOSSAN corridor as well as the three alternatives associated with the inland I-15 corridor. This region is heavily constrained in terms of implementing a new HSR corridor. The previous corridor evaluation study performed for the Commission considered both Mission Valley and Penasquitos Canyon as alternatives for crossing from the I-15 corridor to access Downtown San Diego. Since then, these two alternatives have been determined infeasible due to known environmental and physical constraints.

**EXHIBIT 3-12**  
**SAN DIEGO EVALUATION**  
**KEY CONSTRAINTS/ISSUES**

Key Constraints / Issues	
Miramar Road	
DOWNTOWN	AIRPORT
<ul style="list-style-type: none"> <li>■ Right of Way @ Miramar NAS</li> <li>■ Highly Constrained Right of Way</li> <li>■ Existing Rail Services</li> <li>■ Limited Area for Station Parking</li> <li>■ Limited Freeway Access to Station</li> <li>■ Major Floodplain Encroachment</li> <li>■ Historic Property Impacts</li> <li>■ High Visual Impacts</li> </ul>	<ul style="list-style-type: none"> <li>■ Right of Way @ Miramar NAS</li> <li>■ Major Floodplain Encroachment</li> <li>■ High Visual Impacts</li> </ul>
SR-52	
DOWNTOWN	AIRPORT
<ul style="list-style-type: none"> <li>■ Construction in Freeway Corridor</li> <li>■ Highly Constrained Right of Way</li> <li>■ Existing Services</li> <li>■ Limited Area for Station Parking</li> <li>■ Limited Freeway Access to Station</li> <li>■ Historic Property Impacts</li> <li>■ Highest Potential for T&amp;E Species Impacts</li> <li>■ High Visual Impacts</li> </ul>	<ul style="list-style-type: none"> <li>■ Construction in Freeway Corridor</li> <li>■ Highest Potential for T&amp;E Species Impacts</li> <li>■ High Visual Impacts</li> </ul>
I-15	
QUALCOMM	
<ul style="list-style-type: none"> <li>■ Construction in Freeway Corridor</li> </ul>	<ul style="list-style-type: none"> <li>■ No Direct Service to San Diego</li> </ul>

Notes: All Alternatives from Mira Mesa to Terminal Station.

Exhibit 3-11 presents the key evaluation factors, capital cost, travel time, length, ridership and revenue and operations and maintenance costs for both technologies for the I-15 corridor alternatives. The LOSSAN corridor is presented separately in Section 3.4. The key constraints and issues for each of the alternatives are summarized in Exhibit 3-12. Table H-1 through H-6 in Appendix J lists the key environmental issues associated with each of the alternatives.





### Qualcomm Stadium

Utilizing the I-15 corridor would require construction of the dual track HSR line within the existing and planned freeway corridor to the maximum extent possible in order to minimize impacts on adjacent communities. For the 7 mile stretch from the SR-52 south to the terminus at Qualcomm Stadium, this would require the use of an elevated guideway (*Exhibit 3-13*) due to the limited available right of way. However, based on the existing infrastructure and planned improvements to I-15, available right of way for column placement is very limited and additional right of way will be necessary in some areas. The need to maintain traffic flow on the freeway during HSR construction is another constraint.

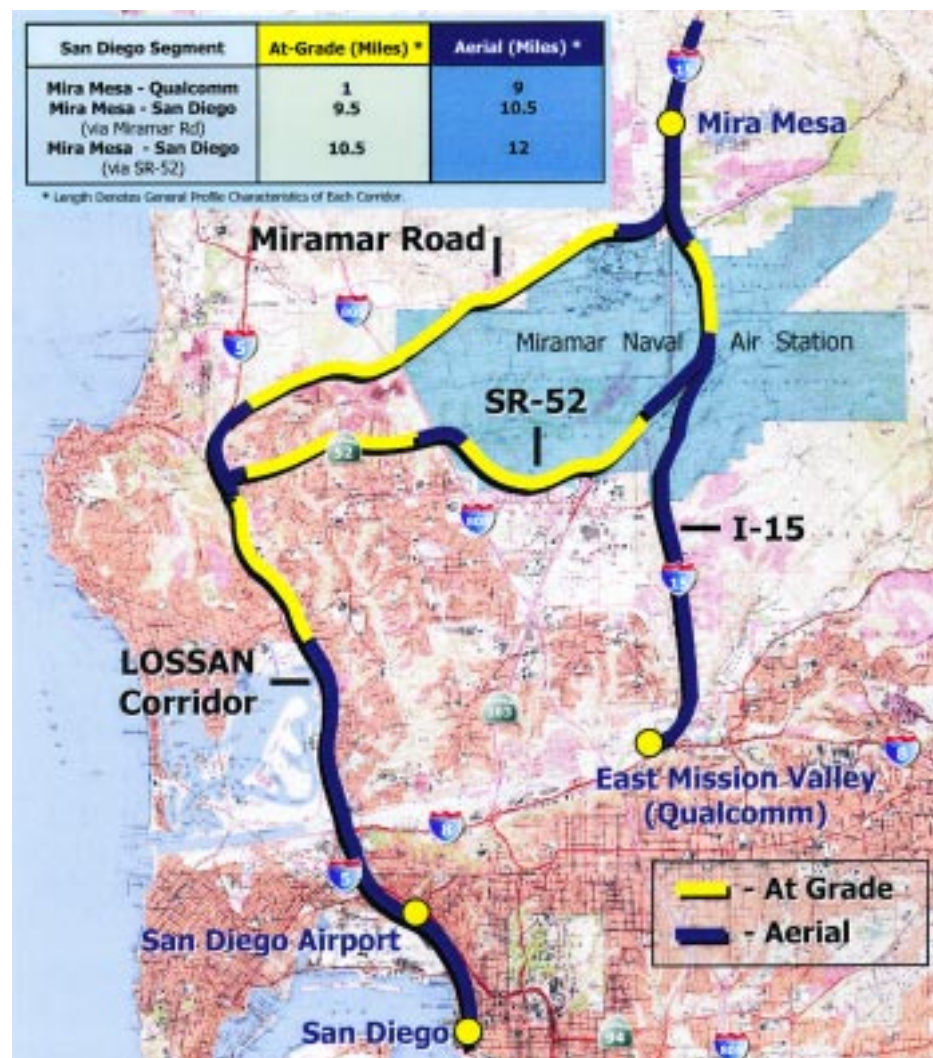
While this corridor does not provide direct service to San Diego, it is forecasted to have slightly higher ridership and revenue than either the Miramar Road or SR-52 corridors. The location does have good freeway access and also provides for transfers to the San Diego Trolley system, which then serves the downtown area. In addition, it is approximately 12 to 14 miles shorter and costs 40%-50% less than the alternatives serving downtown San Diego.

This corridor would have the least potential for environmental impacts compared to the alternatives serving either the airport or downtown. It would, however, have the potential to affect threatened and endangered species and result in visual quality impacts caused by the elevated guideway.

### Miramar Road

The Miramar Road corridor is a highly constrained major arterial corridor. The north side of the street is a heavily developed commercial area, which would require elevating the HSR guideway in order to maintain access to the adjacent development. An elevated guideway would have land use and visual impacts in this corridor. In comparison,

**EXHIBIT 3-13**  
**SAN DIEGO AREA PROFILE CHARACTERISTICS**





the south side of the street belongs to the Miramar Naval (Marine Corps) Air Station (MCAS) and is developed with base housing and other facilities immediately adjacent to the roadway (*Exhibit 3-14*). These facilities would be directly affected. Furthermore, MCAS has indicated that the majority of development and sensitive uses are located along the northern end of the base and would not favor any HSR alignment in this area.

#### SR-52

The SR-52 between I-15 and I-805 also passes through MCAS Miramar. Along this portion, the freeway has relatively small radius horizontal curves and steep grades, necessitating additional right of way acquisition for an HSR alignment and thereby impacting some undeveloped MCAS property and some adjacent developed properties. While the MCAS has not indicated support for any alignment in or near the base, this alternative provides the most flexibility for minimizing impacts on the base due to the absence of existing MCAS facilities in this portion of the base.



From the I-805 to the I-5, the HSR line could remain within the SR-52 right of way corridor. With minor widening and modification the existing median allows for implementation of a dual track HSR line primarily at grade with crossing arterial facilities passing under the freeway. This alternative costs \$257 million more and is 1.8 miles longer than the Miramar Road option.



#### Miramar Road and SR-52 (Common)

From the I-5/SR-52 junction to the line terminus at either the airport or downtown, the Miramar Road and SR-52 corridors follow a common alignment. This common portion follows the existing LOSSAN rail corridor, which provides HSR the opportunity to

share right of way to some extent. This option requires the construction of new, dedicated HSR tracks adjacent to the existing tracks. As the corridor passes along the eastern side of Mission Bay, numerous grade crossings and limited corridor width would require elevating the HSR line. Elevating the HSR through this area would result in substantial visual impacts along Mission Bay. Other environmental issues associated with the common alignment is the potential to impact habitat for threatened and endangered wildlife species, coastal wetlands, cultural resources such as Old Town San Diego, hazardous materials/waste sites, and parks.

From the airport to downtown, the existing corridor is completely filled with existing rail and light rail transit infrastructure (*Exhibit 3-15*) and again requires placing the HSR tracks above and adjacent to the existing track to achieve grade separation.

This would directly impact the intensive commercial land uses that are adjacent to the corridor. Placing the terminal station in downtown versus the airport site will cost an additional \$118 million and have very little impact on ridership and revenue. The downtown station site has limited freeway access and limited area for station parking. The airport station allows for better freeway access as well as easy transfers to the airport or light rail transit. Environmentally, the segment from the airport to downtown would have additional impacts to cultural resources, visual quality, and land use in the downtown area.



## Los Angeles Region

There are numerous alternatives to serve the expansive Los Angeles region including existing freeway and rail corridors. The alternative corridors considered in this evaluation were limited to existing rail corridors for the following reasons. First, the density and extent of development in the area inhibit the development of a new corridor. Second, the alignment geometry (e.g., horizontal curves) of freeway alignments is very restrictive in terms of HSR design speeds as compared to the relatively straight rail alignments. Third, freeway corridors are generally more constrained in terms of available right of way and density of surrounding development. In addition, the types of land use adjacent to freeway corridors (e.g., residential commercial) are typically not compatible with rail lines. However, operating HSR within existing rail corridors would not eliminate impacts on adjacent communities. In most cases, there is not enough available existing right-of-way for

EXHIBIT 3-16  
LOS ANGELES AREA EVALUATION VHS/MAGLEV



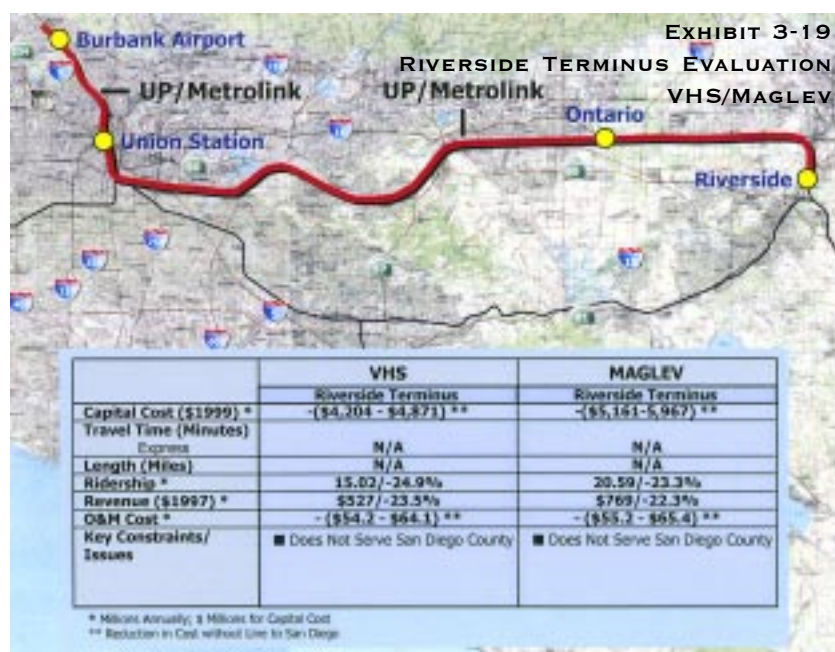
EXHIBIT 17  
LA AREA UP CORRIDOR

the HSR tracks, which will necessitate purchasing properties adjacent to the corridors for HSR. These corridors are further constrained by the existing rail infrastructure and service, which would require measures to insure safety when different types of trains operate on adjacent tracks.

## Inland Empire

There were two alternatives to serve the Inland Empire, either along the UP/Metrolink corridor through Los Angeles and San Bernardino Counties or the SR-91/BNSF/Metrolink corridor through Los Angeles, Orange and Riverside Counties. The existing rail infrastructure, including existing passenger service, along these lines would constrain the construction and operation of the HSR line. The evaluation of each is presented in *Exhibit 3-16* for VHS and Maglev technology .





### UP/Metrolink Ontario-Riverside (Baseline)

The HSR tracks would be constructed at-grade and adjacent to the existing tracks along the UP/Metrolink corridor wherever possible. Although this corridor is relatively open east of Ontario (*Exhibit 3-17*) frequency of existing at-grade crossings and other development constraints require the HSR line to be elevated in several locations (*Exhibit 3-18*). The Ontario Airport station would allow HSR passengers to connect to air transportation and also provide convenient access to the I-10, I-15, and SR-60 freeways. Although this option provides better service for the Inland Empire since it serves both San Bernardino and Riverside counties, it does not serve Orange County. This alternative provides the fastest service to the Inland Empire and the I-15 corridor to San Diego, approximately 15 minutes shorter (express) than the SR-91 corridor at a capital cost \$770 million lower. This option has less potential for significant environmental impacts than the SR-91 alternative as well. This alternative could also serve as a branch alignment terminating in Riverside as an initial phase of the project or permanently if the LOSSAN corridor was implemented instead of the inland route. The potential savings associated with terminating this alignment in Riverside and the effects on ridership and revenue is shown in *Exhibit 3-19*.

This corridor has the potential to affect minority populations in portions of Los Angeles and San Bernardino counties. Environmental issues associated with this corridor include impacts to the California Gnatcatcher, a threatened and endangered species located in the rural areas; numerous water crossings including several natural drainages such as the Santa Ana River; and visual quality impacts resulting from an elevated guideway through Riverside. Additionally, there are a number of cultural resources located along the corridor including Union Station and properties in Pomona and Ontario.



**EXHIBIT 3-20**  
**LA AREA BNSF CORRIDOR**



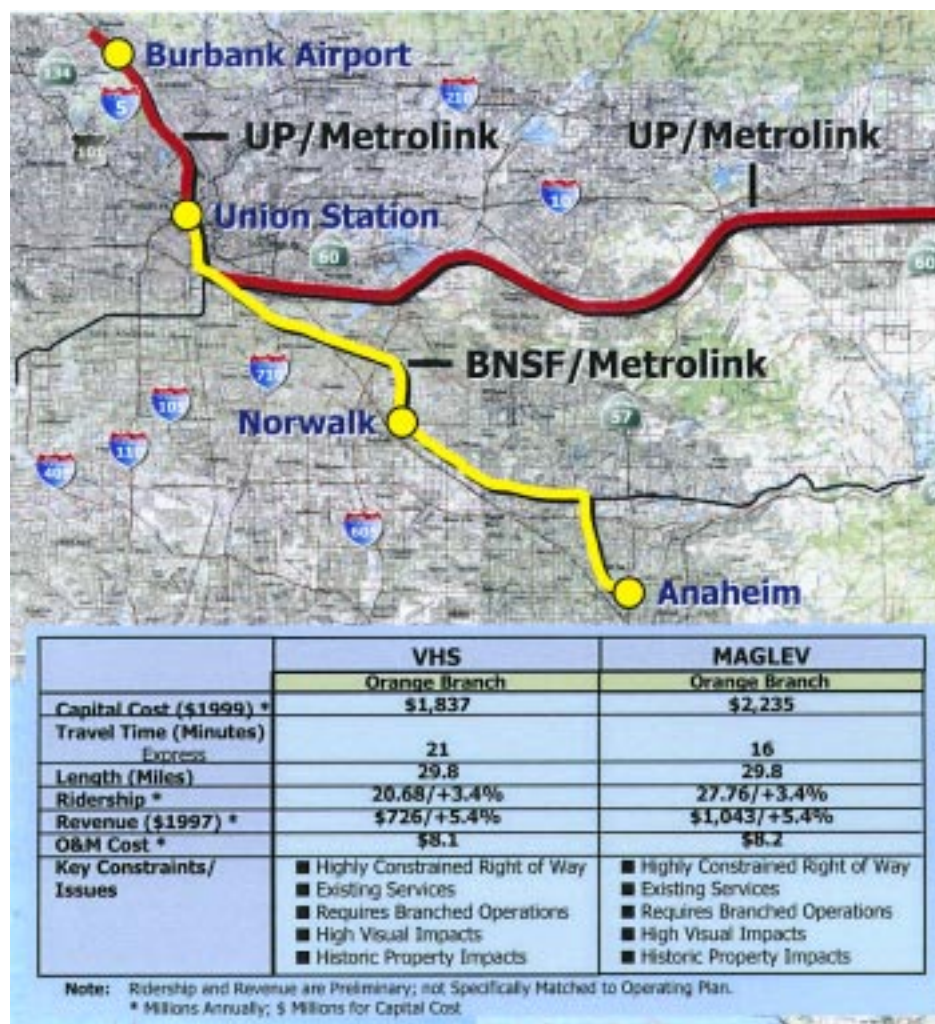
SR-91/Metrolink Corridor from Orange County

The HSR tracks would be constructed at-grade and adjacent to the existing tracks along the BNSF/Metrolink corridor wherever possible. This corridor is heavily constrained through Los Angeles and Orange Counties. In the Santa Ana Canyon area of Orange County, development constraints coupled with difficult terrain and sensitive environmental concerns of the Santa Ana river pose significant constraints to a new HSR line (*Exhibit 3-20*). These constraints necessitate the greater use of elevated guideway and substantial fill areas (*Exhibit 3-18*), which would result in visual quality impacts. The constraints and the curvatures of the existing corridor limit the speeds resulting in slower travel times and increases in the capital costs as well. This option provides service to Orange and Riverside Counties, though it does not serve San Bernardino County (i.e., Ontario Airport). This alternative would have a number of substantial environmental impacts in addition to visual quality, including floodplain encroachment and sensitive habitat along the Santa Ana River; impacts to minority populations in Los Angeles and Orange counties; parks and recreation impacts to Featherly Regional Park and Chino Hills State Park; and a number of hazardous materials/waste sites through Los Angeles, Santa Fe Springs, and Riverside. Other sensitive resources include Union Station and historic properties in Fullerton and Riverside.

A station stop at the Fullerton Transportation Center Station would allow passengers to transfer to a variety of other transportation systems, including Amtrak, Metrolink and the OCTA bus transit system. The downtown Riverside station would also provide connections with Metrolink and the RTA bus transit system.



**EXHIBIT 3-21**  
**ORANGE BRANCH EVALUATION - VHS/MAGLEV**



### **Orange County**

Three alternatives were considered for serving Orange County. All three utilize the northern portion of the LOSSAN corridor (BNSF/Metrolink between Los Angeles and Fullerton). The three alternatives consist of a branch alignment terminating in Anaheim, as part of through service to San Diego via the SR-91 Inland Empire route, or as part of through service to San Diego via the LOSSAN corridor.

#### Orange County Branch Terminus

The evaluation of this alternative is presented in *Exhibit 3-21*. This option provides HSR service along the existing BNSF/Metrolink corridor south from Los Angeles to Anaheim. This corridor is highly constrained by existing rail infrastructure and development. The HSR tracks would be located at-grade and adjacent to the existing tracks from Union Station to Fullerton and an elevated guideway would be required from Fullerton south to Anaheim (*Exhibit 3-18*) due to the number of existing grade crossings and intensity of land uses. The negative aspects of this alternative include high visual quality impacts due to the elevated guideway and impacts on historic properties along the corridor. Stations at both the Fullerton Transportation Center and Anaheim serve the county's residents better than the SR-91 option with only one station. This alternative does not provide service to San Diego and would therefore be in addition to an inland Los Angeles-San Diego route. From an operations standpoint, there are some drawbacks to branched alignments. Branched alignments are less efficient than single lines, wherein every train can serve each station. In contrast, on a branched line separate trains are required to serve each branching direction. However, realizing the limitations, branched routes are used successfully on many major rail transit systems.



#### SR-91/Metrolink Corridor

The evaluation of this corridor was presented in *Exhibit 3-16* as part of the Inland Empire alternatives. This option provides service to Orange County as part of through service to San Diego, which, from an operations standpoint, is preferable to a branch alignment. However, only one station is located in Orange County, Fullerton, which is well connected with other modes of transportation but does not serve central and south county populations. The other aspects of this alignment were discussed in the Inland Empire section.

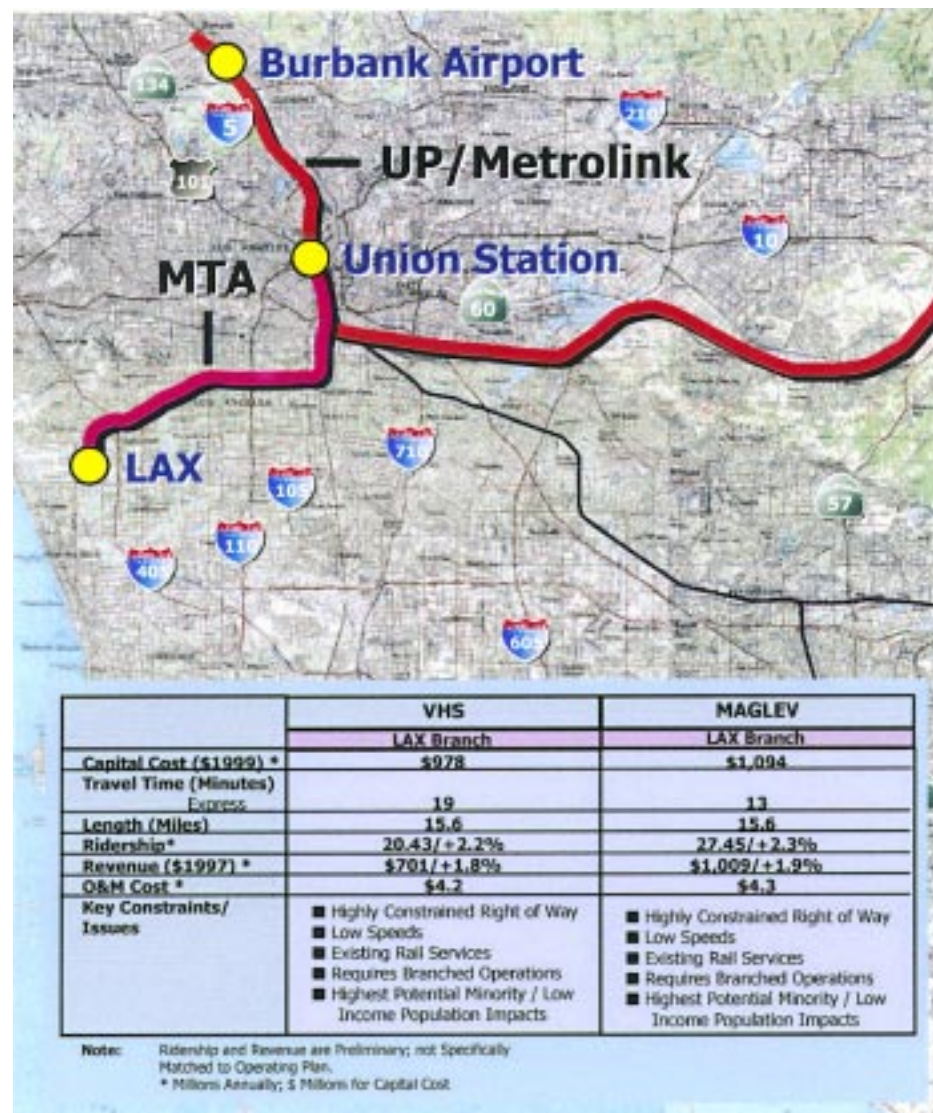
#### LOSSAN Corridor

The evaluation of the LOSSAN corridor is presented in Section 3.4

#### Los Angeles to LAX

The analysis of the Los Angeles to LAX alternative is presented in *Exhibit 3-22*. Given the dense development in the region, the only viable corridor for connecting Union Station with the Los Angeles Airport follows the existing BNSF corridor. The right-of-way for this corridor is highly constrained in terms of the type and intensity of land uses and number of existing grade crossings, which requires elevating the HSR guideway throughout (*Exhibit 3-18*). The circuitous nature of the existing corridor (i.e. curve radii) greatly limits the speeds. A trip from Union Station to LAX will take 19 minutes, which is an average speed of only 50 mph. This performance could be achieved with other forms of rail transit. This corridor also has high potential impacts on minority and low-income populations. This segment would operate as a branch line.

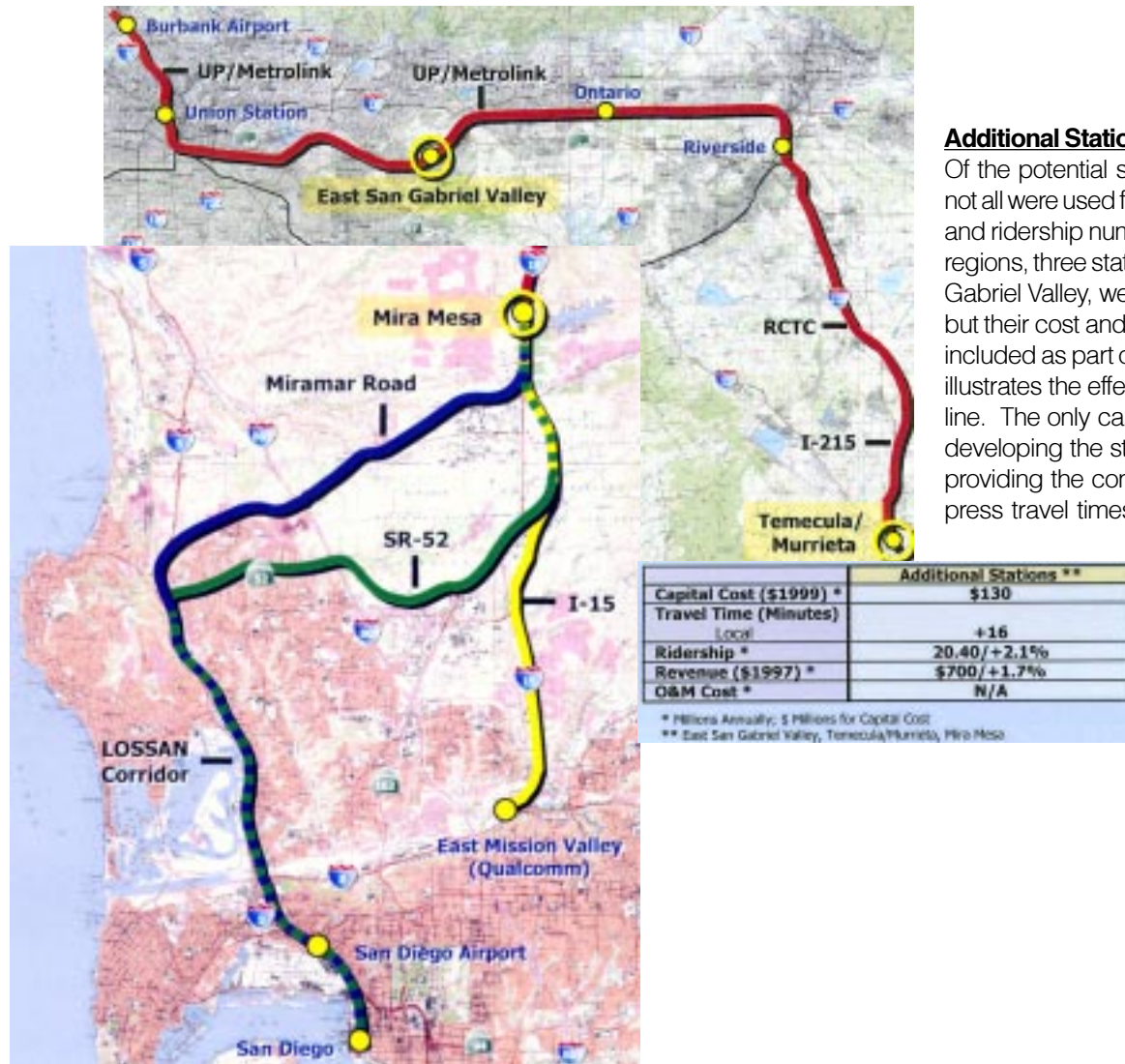
EXHIBIT 3-22  
LAX BRANCH EVALUATION VHS/MAGLEV





# EXHIBIT 3-23

## LOS ANGELES AREA AND SAN DIEGO AREA - ADDITIONAL STATIONS



### Additional Stations

Of the potential stations associated with each alternative, not all were used for developing the alternative's capital cost and ridership numbers. In the San Diego and Los Angeles regions, three stations, Mira Mesa, Temecula, and East San Gabriel Valley, were identified as potential station locations but their cost and effect on ridership and revenue were not included as part of the alternative's evaluation. *Exhibit 3-23* illustrates the effect of including these stations on the HSR line. The only capital cost for this alternative is the cost of developing the station sites, constructing the stations and providing the connecting trackage, \$130 million. The express travel times would not change if these stations are

added to the line, but the local travel time between San Diego and Los Angeles would increase 16 minutes. Serving these additional communities would increase HSR ridership and revenue, without significantly increasing the impact on the community.



## Tehachapi Crossing

Three alternatives were studied for crossing the Tehachapi Mountains, linking Los Angeles with Bakersfield and the Central Valley (*Exhibit 3-24*). From Los Angeles to Santa Clarita, all of the alternatives follow the UP/Metrolink corridor because development in the area limits the construction of a new corridor. The primary constraint for all of these alternatives is topography (i.e., the Tehachapi Mountains), which influences grades, cost and length of tunneling. The evaluation

EXHIBIT 3-24  
TEHACHAPI CROSSING ALTERNATIVES



of these alternatives is presented in *Exhibit 3-25* for VHS and Maglev technology. Some of the key constraints and issues associated with each corridor are presented in *Exhibit 3-26*.

	VHS		MAGLEV
	I-5 / Grapevine		I-5 / Grapevine
Capital Cost (\$1999) *	\$4,612	\$4,094	\$5,232
Travel Time (Minutes)	48	48	34
Length (Miles)	189.9	100.9	189.9
Ridership *	33.82 / +7.4%	31.83 / +5.3%	28.60 / +6.9%
Revenue (\$1997) *	\$734 / +6.7%	724 / +4.9%	\$1,835 / +5.0%
OMB Cost *	\$109.1	N/A	\$111.2
	Palmdale Aqueduct		Palmdale Aqueduct
	I-5 / Grapevine		I-5 / Grapevine
Capital Cost (\$1999) *	\$5,193	\$4,992	\$6,352
Travel Time (Minutes)	50	57	39
Length (Miles)	145.0	145.0	145.0
Ridership *	18.99 / NA	18.81 / -2.4%	26.83 / NA
Revenue (\$1997) *	\$688 / NA	\$68 / -2.0%	\$998 / NA
OMB Cost *	\$144.3	N/A	\$146.8
	Palmdale / Mojave		Palmdale / Mojave
	I-5 / Grapevine		I-5 / Grapevine
Capital Cost (\$1999) *	\$4,852	\$4,852	\$6,483
Travel Time (Minutes)	50	57	39
Length (Miles)	143.4	143.4	143.4
Ridership *	18.99 / NA	18.83 / NA	26.83 / NA
Revenue (\$1997) *	\$688 / NA	\$998 / NA	\$998 / NA
OMB Cost *	\$142.3	\$145.1	\$145.1

EXHIBIT 3-25  
TEHACHAPI  
EVALUATION  
VHS/MAGLEV

EXHIBIT 3-26  
TEHACHAPI EVALUATION  
KEY CONSTRAINTS/ISSUES

Key Constraints / Issues	
I-5 / Grapevine	
3.5%	5.0%
<ul style="list-style-type: none"> <li>■ Crosses Garlock Fault in Tunnel</li> <li>■ Visual Impacts</li> <li>■ Major Park &amp; Recreation Impacts</li> <li>■ No Antelope Valley Service</li> </ul>	<ul style="list-style-type: none"> <li>■ Visual Impacts</li> <li>■ Major Park &amp; Recreation Impacts</li> <li>■ No Antelope Valley Service</li> </ul>
Palmdale Aqueduct	
3.5%	5.0%
<ul style="list-style-type: none"> <li>■ Crosses Garlock Fault in Tunnel</li> <li>■ Right of Way Constrained in Palmdale Area</li> <li>■ Major Floodplain Encroachment</li> </ul>	<ul style="list-style-type: none"> <li>■ Right of Way Constrained in Palmdale Area</li> <li>■ Major Floodplain Encroachment</li> </ul>
Palmdale / Mojave	
<ul style="list-style-type: none"> <li>■ Major Floodplain Encroachment</li> </ul>	

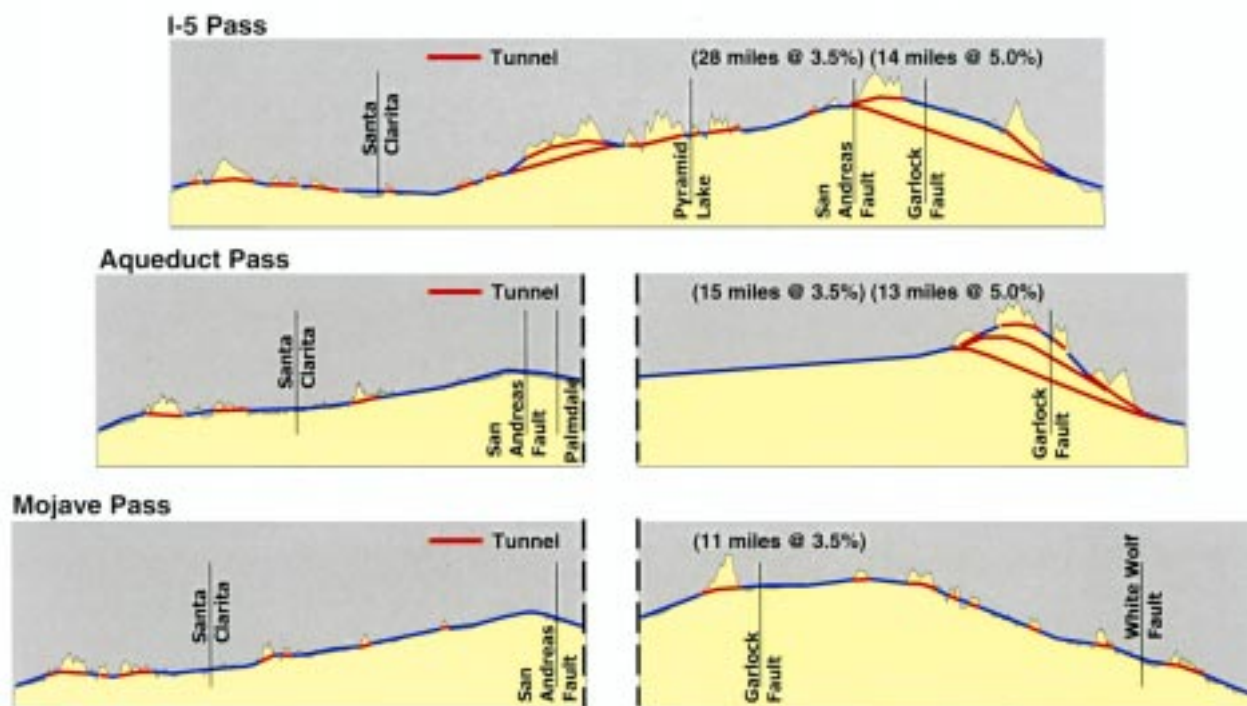


### Antelope Valley/Mojave Pass (Baseline)

This alternative is longer, but the terrain is less abrupt than the other options. 3.5% grades are sufficient to rise above the terrain (*Exhibit 3-7*); therefore, this option requires the least amount of tunneling, approximately 11 miles. Unlike the other two options, the Palmdale-Mojave corridor crosses all major seismic faults at ground level rather than in tunnel. Crossing faults at-grade allows for faster and easier access and repair in case of a damaging seismic event. Also, service is provided to the growing region of the Antelope Valley. However, this alternative is 34 miles longer than the Grapevine corridor with express travel times 9 minutes longer for 3.5% grades (6 minutes longer if 5% grades are used on the Grapevine). Local travel times would be 14 minutes longer for the 3.5% grade. This added length makes the Antelope Valley alternative more expen-

sive than the Grapevine, between \$237 million and \$798 million more for VHS technology (depending on the grades used on the Grapevine alternative). The added nine minutes of travel times negatively affects the forecasted ridership and revenue, estimated to be around 7% higher for the Grapevine. Environmental impacts of this corridor include floodplain encroachment along the Santa Clara River and Soledad Canyon; threatened and endangered species such as the San Joaquin kit fox and California Jewell-flower; park and recreation impacts to the Pacific Crest National

**EXHIBIT 3-27**  
**TEHACHAPI CROSSING PROFILES**





Scenic Trail and Angeles National Forest; hazardous materials/waste sites primarily related to refining and trucking; and potential impacts to low-income populations in the Lancaster area. Approaching Bakersfield, this alignment may either run through Downtown along the BNSF corridor or bypass to the south with a suburban station serving the city. The corridor through downtown Palmdale and Bakersfield is very constrained in terms of existing grade crossings, so the HSR guideway would have to be elevated in those sections, resulting in visual quality impacts.

#### Aqueduct Pass

The terrain covered by this alternative is more abrupt than that of the Antelope Valley corridor. At a maximum grade of 3.5%, 15 miles of tunnel are required while 5% grades can reduce that amount to 13 miles. Some of the issues associated with the maximum desirable grades were discussed in Chapter 2 – Design Parameters. In addition to those already addressed is the potential for crossing major fault lines in tunnel. At 3.5% maximum grade, this alignment would cross the Garlock fault in tunnel while 5% grades would place the alignment at-grade when crossing the fault. This alignment also provides service to the Antelope Valley region. This alignment is the longest, 35 miles longer than the Grapevine and 9 minutes longer for

travel times (for either maximum grade on Grapevine). The 5% grades add 3 minutes to the travel times, which is forecasted to reduce ridership and revenue by 2-3% as compared to the Palmdale-Mojave alternative. As with the Antelope Valley corridor, environmental impacts of this corridor include floodplain encroachment; threatened and endangered species including the San Joaquin kit fox and blunt-nosed leopard lizard; crossing of numerous natural and channelized drainages; and potential impact to the Antelope Valley California Poppy Reserve.

#### I-5/Grapevine

This corridor crosses the most difficult terrain of any of the alternatives. At 3.5% grades, 28 miles of tunneling are necessary while 14 miles of tunneling are needed at 5% grade. As with the Aqueduct Pass, the Grapevine alignment would cross the Garlock fault in tunnel if 3.5% grades are used but not if 5% grades are chosen. This alignment would not provide service to Palmdale and the Antelope Valley. The Grapevine corridor has the shortest length and therefore the fastest travel times, the lowest capital cost, and the highest projected ridership and revenue. Environmental impacts would be more substantial for the 5% grade alignment than for the 3.5% grade alignment. This is due to less tunneling which would result in additional visual impacts; parks and recreation impacts at Fort Tejon State Historic Park and Castaic Lake; and potential direct or indirect impacts to historic Fort Tejon. Environmental issues common to both the 3.5% and 5% grade alignments include floodplain encroachment along Grapevine Creek and the Santa Clara River; water resources and crossings including Pyramid Lake and Castaic Lake; threatened and endangered species; hazardous materials/waste sites; and potential impacts to low-income populations in the Castaic area.

## Central Valley Alternatives

There were four alternatives studied for the Central Valley, two following existing rail corridors and two new corridors to the west and east of SR-99 (*Exhibit 3-28*). The disruption of farmland and the impact on communities are the primary constraints for the Central Valley alignments. The evaluation of these four alternatives is presented in *Exhibit 3-29* for VHS technology. The key constraints and issues for each are presented in *Exhibit 3-30*.

**EXHIBIT 3-29**  
**CENTRAL VALLEY EVALUATION - VHS/MAGLEV**

VHS	West 99 (1)	UP (1)	BNSF (1)	East 99 (1)
Capital Cost (2)	\$3,658	\$6,826	\$5,148	\$4,168
Travel Time (Minutes)				
Express	62	64	74	69
Length (Miles)	212	218	221	235
Ridership (3)	20.02/NA	20.02/NA	NA	NA
Revenue (4)	\$688/NA	\$688/NA	NA	NA
O&M Cost (5)	\$210	\$216	\$219	\$233

MAGLEV	West 99 (1)	UP (1)	BNSF (1)	East 99 (1)
Capital Cost (2)	\$6,513	\$9,569	\$8,184	\$7,171
Travel Time (Minutes)				
Express	44	45	51	48
Length (Miles)	212	218	221	235
Ridership (3)	26.87/NA	26.87/NA	NA	NA
Revenue (4)	\$990/NA	\$990/NA	NA	NA
O&M Cost (5)	\$215	\$221	\$224	\$238

Note: (1) Limits of Comparison (Bakersfield to Manteca)  
(2) In Millions of 1999 Dollars  
(3) In Millions of Annual Passengers for Statewide System/% Change from Baseline  
(4) In Millions Annually for Statewide System (1997 Dollars)/% Change from Baseline  
(5) In Millions Annually (1999 Dollars)

**EXHIBIT 3-30**  
**CENTRAL VALLEY EVALUATION - KEY CONSTRAINTS/ISSUES**

Key Constraints / Issues	
West 99	UP
<ul style="list-style-type: none"> <li>High potential farmland impacts</li> <li>High potential land use impacts (parcel splits)</li> </ul>	<ul style="list-style-type: none"> <li>Highly constrained R/W through cities</li> <li>High potential for historic property impacts</li> <li>High potential farmland impacts</li> </ul>
BNSF	East 99
<ul style="list-style-type: none"> <li>Highly constrained R/W through cities</li> <li>Lower speeds in Fresno</li> </ul>	<ul style="list-style-type: none"> <li>High potential farmland impacts</li> <li>High potential for water resource impacts</li> <li>High potential land use impacts (parcel splits)</li> </ul>

**EXHIBIT 3-28**  
**CENTRAL VALLEY ALTERNATIVES**





#### East of SR-99

This corridor follows both existing and new rail corridors lying to the east of SR-99. This is the longest of the Central Valley alignments, approximately 23 miles longer than the West of 99 alignment, which is the shortest alternative. Since it is longer, its travel time is also 7 minutes longer as compared to the West of 99 option and its capital cost \$510 million higher (for VHS service).

Since this is a new corridor, there is a high potential for land use impacts; meaning corridor alignment may cause parcel splits. Parcel splits divide property, disrupting the owner's access to his land. Therefore, they are generally viewed as undesirable. Mitigations for these impacts require fair market value for the land and provision of crossings. Minimizing and avoiding the potential for property severance during the preparation of specific alignments is key to maintaining the viability of the alternative corridor. Alignments along existing highways, railways and property lines can be used to limit the potential for severance issues.

The Fresno Airport station would allow HSR passengers to connect with other modes of transportation. On the downside, the remote stations will require passengers to transfer to other forms of transportation to reach urban centers. Through Fresno, development constrains the corridor and an elevated guideway would be necessary which would result in visual quality impacts. There is also a high potential for farmland and water resource impacts within this corridor. Farmland required within this corridor includes approximately 150 acres, 65% of which is considered prime farmland. Water resources within this corridor include numerous natural and channelized drainages including 12 rivers. This corridor also has the potential to impact both low-income and minority populations, particularly through Merced and Bakersfield. Other potentially significant environmental impacts include threatened and endangered

species and floodplain encroachment. There are several sensitive species within the corridor including the valley elderberry long-horned beetle, the giant garter snake, as well as several vernal pool species; and floodplain encroachment around major water crossings.

#### West of SR-99

This corridor follows a new alignment parallel and to the west of SR-99. This is the shortest of the Central Valley alignments and correspondingly has the shortest travel times and lowest capital cost. As with the East of 99 option, a new corridor leads to a high potential for causing parcel splits and disrupting farmland operations. Farmland impacts within this corridor would amount to approximately 180 acres, 57% of which is considered prime farmland. Steps must be taken in developing specific alignments to avoid or minimize these impacts. Also, the capital cost estimates currently include reasonable provision for crossings along this alignment. Since this corridor passes to the west of the major Central Valley cities, impacts on communities are minor. However, direct service is not provided to city centers.

Major environmental issues within this corridor include ten major river crossings; floodplain encroachment at major water crossings; potential impacts to sensitive species such as the San Joaquin kit fox and San Joaquin woollythreads; and impacts to minority populations within Bakersfield.

#### BNSF Rail Corridor

The HSR tracks would be at-grade and adjacent to the existing corridor. The HSR tracks could share portions of the existing BNSF right-of-way where space exists. Of course this right of way must be purchased whether part of the BNSF corridor or other property adjacent to the corridor. In urban areas, this corridor is highly constrained, which would require elevating the guideway in some places. Another constraint is the existing BNSF rail infrastructure and service, which will require measures to insure safety when HSR operates on adjacent tracks, either through adequate separation or the use of crash walls. This corridor is 9 miles longer than the West of 99 alternative and costs \$1,490 million more for a VHS system. The higher cost is primarily due to additional length of this alternative and more extensive infrastructure needs in the developed areas. In addition, there are several speed limiting curves along the corridor. In undeveloped areas, it is possible to purchase right-of-way so the HSR corridor meets the necessary geometric standards for maximum operating speeds. However, when these curves



occur in developed areas, corridor realignment is impossible and HSR performance is affected. Since there are several speed limiting curves within urban areas along this corridor, the BNSF alternative has the longest travel time, 12 minutes longer than West of 99. This option better serves the urban centers of the Central Valley, though this also negatively impacts the community more. Since this alignment follows an existing corridor, it would have fewer potential land use and farmland impacts, even when additional right-of-way is required. This corridor would, however, still impact approximately 103 acres of farmland of which 70% is considered prime farmland. This alignment would also have the potential to affect low-income populations in the Merced area and impacts to minority populations in Bakersfield, Fresno and Merced. There are also a number of threatened and endangered species within the corridor such as vernal pool fairy shrimp and the Tipton kangaroo rat. Many natural and channelized drainages cross the corridor including seven major rivers. This corridor would also encroach upon several floodplains which follow the major rivers. Other environmental issues include parks and recreation impacts at Pixley National Wildlife Refuge and Allensworth State Historical Park; historic resources located along the alignment; visual impacts; and numerous hazardous materials/waste sites throughout the corridor.

#### UP Corridor

The HSR tracks would be at-grade and adjacent to the existing tracks, potentially sharing a portion of the UP right-of-way where available. As with the BNSF, the use of this right-of-way must be purchased along with any additional right-of-way needed adjacent to the corridor. The UP corridor passes directly through the urban center of every major Central Valley city. HSR improvements within this corridor have the potential to affect low-income and minority populations within Merced, Turlock and Modesto. The corridor also has the potential to affect minority populations in Bakersfield and Atwater. The corridor right-of-way through these cities is constrained by development, requiring segments of elevated guideway in some developed areas, which has a negative visual impact on the adjacent community. The UP alignment is six miles longer than the West of 99, resulting in a 2 minute longer travel time (VHS). However, this travel time may increase by 15 minutes if speeds through the urban areas are limited to 125 mph (*Exhibit 3-31*). Since this corridor passes through more urbanized areas than the other corridors, it has the highest capital cost, \$3,168 million more than the West of 99 option. The higher costs are primarily due to the higher portion of alignment passing through developed areas and the associated infrastructure (e.g. grade separations) required through these areas.

While this corridor would extend along existing tracks, additional right-of-way would be required. Farmland impacts for this corridor were the highest of all Central Valley corridors with approximately 250 acres, 71% of this being prime farmland. This alignment would have the potential to affect low-income and minority populations in the Modesto, Turlock, and Merced areas. Other minority population impacts are also possible in Atwater and Bakersfield. Like the BNSF corridor, threatened and endangered species within the corridor include vernal pool shrimp and the Tipton kangaroo rat. There are a total of ten major rivers that cross this corridor including the Stanislaus River, San Joaquin River, and Kings River. This corridor would also encroach upon several floodplains that follow the major rivers. Other environmental issues include potential parks and recreation impacts at the Stanislaus Fairgrounds and McConnel State Recreation Area; historic resources located along the alignment; visual impacts; and numerous hazardous materials/waste sites throughout the corridor including chemical, petroleum and aviation sites.

**EXHIBIT 3-31**  
**CENTRAL VALLEY REDUCED SPEED ALTERNATIVE**  
**VHS/MAGLEV**

	VHS	MAGLEV
	Reduced Speed Alt (1)	Reduced Speed Alt (1)
Capital Cost (2)	\$5,826	\$9,569
Travel Time (Minutes)		
Express (3)	+15	+15
Length (Miles)	218	218
Ridership (4)	18,93/-5.4%	25,72/-4.3%
Revenue (5)	\$639/-7.2%	\$936/-5.4%
O&M Cost (6)		

**Note:** (1) Units of Comparison (Bakersfield to Merced)  
(2) In Millions of 1999 Dollars  
(3) Net Additional Travel Time given reduced speed of 125mph  
(4) In Millions of Annual Passengers for Statewide System % Change from Baseline  
(5) In Millions Annually for Statewide System (1997 Dollars) % Change from Baseline  
(6) In Millions Annually (1999 Dollars)



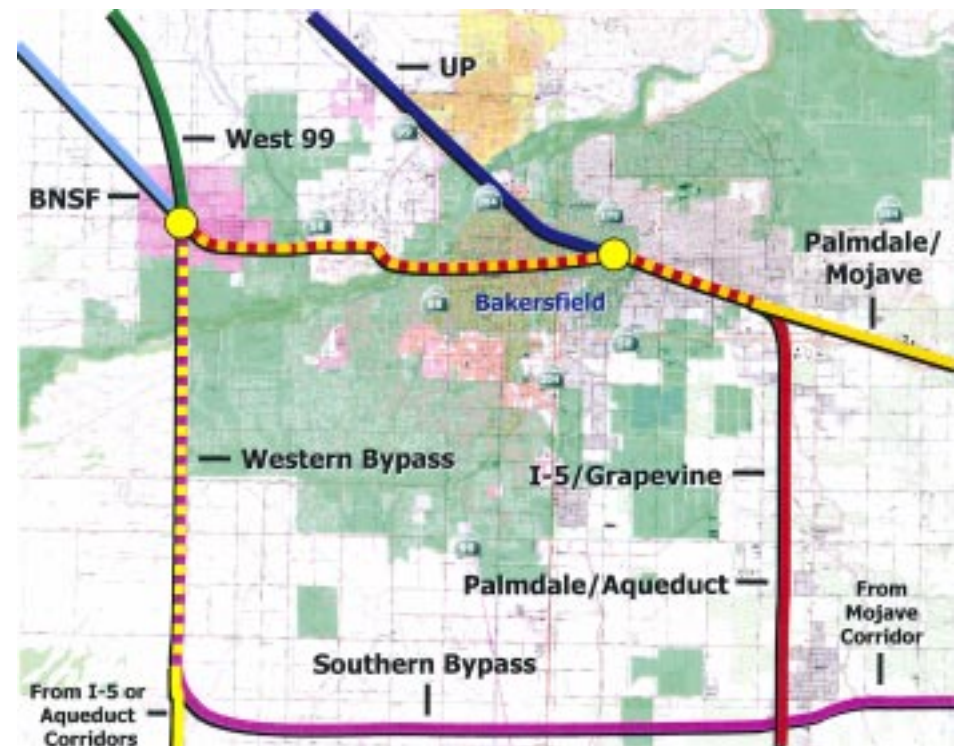
### **Central Valley Community Constraints**

Within the Central Valley, the HSR's effect on the communities of Bakersfield and Fresno requires additional consideration. The placement of the line and stations relative to the cities has implications on the cost, ridership, and impacts of HSR. While a suburban bypass reduces the impacts on the community and lowers the capital costs, HSR passengers must use other forms of transportation between the city center and the station.

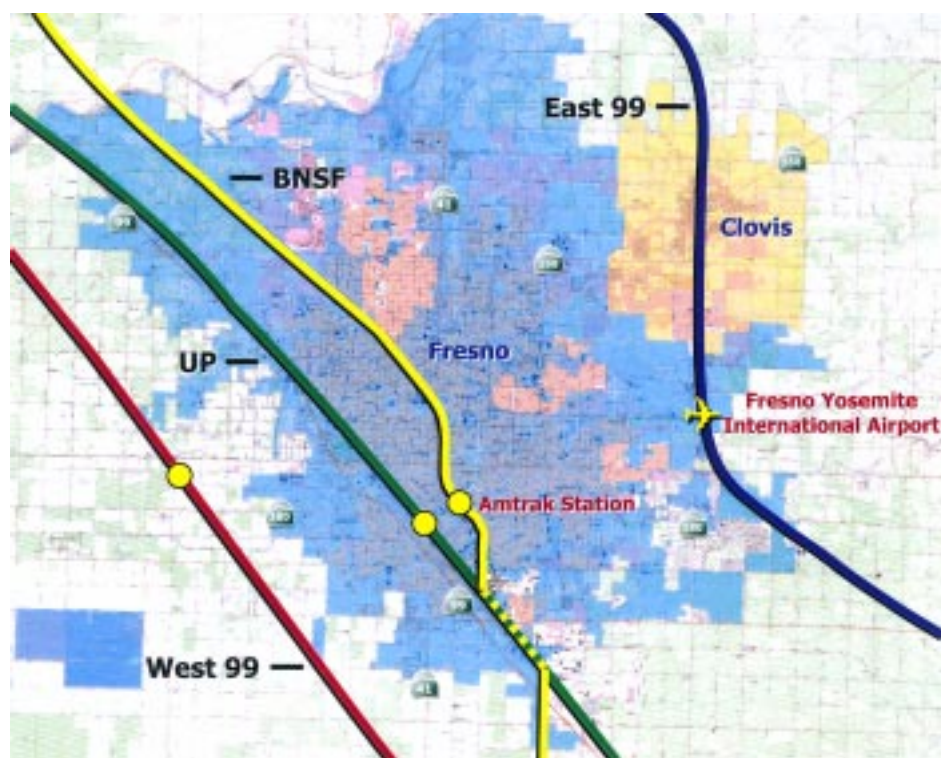
In Bakersfield, numerous alternative alignments were studied as illustrated in *Exhibit 3-32*. The possible alternatives are dependent on joining the Tehachapi Crossing with the Central Valley alignment. With the Grapevine and Aqueduct corridors, alignments through downtown or bypassing to the west of the city are viable alternatives. The western bypass can connect with the West of SR-99, BNSF, UP and East of SR-99 Central Valley corridors, which would reduce travel times along those routes. Since the HSR line and station would be located outside the city, there would be less impact on the urbanized area and lower costs in general. However, passengers to and from the city center would have to utilize other transportation. A downtown alignment would run along an elevated guideway through the center of the city and have higher environmental impacts and capital costs.

For the Palmdale/Mojave corridor, two viable alternatives were identified, either through downtown as described before or along a southern route skirting the developed areas of Bakersfield and joining the western bypass. A northern bypass was also considered but determined to be infeasible due to development constraints and existing oil fields in the area. This southern route adds approximately 10 miles to the route

**EXHIBIT 3-32**  
**CENTRAL VALLEY - BAKERSFIELD**



**EXHIBIT 3-33**  
**CENTRAL VALLEY - FRESNO**



and is similar in terms of capital cost to the more direct downtown route.

The choice of alternative routes through the Tehachapi crossing and the Bakersfield area has a significant cumulative effect on capital cost. For example, a corridor comprised of the I-5 Grapevine alternative using the western bypass route through Bakersfield and connecting to the West of 99 Central Valley route is over \$680 million less than a corridor comprised of the Palmdale-Mojave alternative passing through downtown Bakersfield and connecting with the West of 99 route.

In Fresno, the alternatives are limited to the four Central Valley options as illustrated in *Exhibit 3-33*. Only the West of SR-99 option bypasses development, the other three options pass through some portion of the city. The development constraints of these 3 options increase their capital cost as compared to the West of 99 option. The East of 99 alternative divides the community of Clovis as studied and an eastern bypass for this alignment is not viable at high speeds (over 200 mph) due to the curves required to access the Fresno-Yosemite International Airport. For the UP corridor, development does not affect travel times unless speeds are restricted through the city. The BNSF corridor, however, has several speed limiting curves in Fresno which increase the travel time.





## Bay Area Access Alternatives

There were two options for approaching the Bay Area, either from the south using the Pacheco Pass to cross the coastal mountains or from the east utilizing the Altamont Pass (Exhibit 3-34). The evaluation of these two alternatives is presented in Exhibit 3-35 for the two technologies while the key issues associated with each are presented in Exhibit 3-36.

### Altamont Pass

This corridor turns west from the Central Valley alignment just south of Stockton. The location of the coastal mountain crossing has implications on the travel times between Sacramento and San Francisco. Since this is the northerly option, the travel time is faster than that of the Pacheco Pass, almost 50 minutes less for an express trip with VHS technology and 35 minutes less for Maglev. The Sacramento to San Francisco express travel time, 59 minutes for VHS service and 44 minutes for Maglev, would be very competitive with other forms of transportation in this market. The travel times are less competitive from Southern California. The travel time to San Francisco from the south (e.g., Los Angeles) is 3 minutes faster for this option but the time to San Jose from the south is 10 minutes longer than with the Altamont Pass.

With this alternative, a branch alignment is needed to serve San Jose. As discussed previously, branched alignments can negatively impact the frequency of service provided to the stations along the branches. This impact is more noticeable in this case, wherein both termini (San Jose and San Francisco) are the destinations of a large portion of the passengers. In this case, the result is less frequent service to the two termini unless additional trains (i.e. above the baseline concept) are provided. This alternative requires less

EXHIBIT 3-35  
BAY AREA ACCESS - ALTAMONT PASS, PACHECO PASS



VHS	Altamont		Pacheco Pass	
	SAN JOSE	SAN FRANCISCO	SAN JOSE	SAN FRANCISCO
Capital Cost (1)	\$2,659	\$5,235 (6)	\$4,379	\$7,295
Travel Time (Minutes)				
Express (2)	49	62	39	55
Local	75	98	49	70
From Sac. - Express	47	59	82	108
Length (Miles)	60	89	103	147
Ridership (3)	26.82/NA		21.82/5.5%	
Revenue (4)	\$688/NA		\$744/9.0%	
O&M Cost (5)	\$52	\$70	\$73	\$104

MAGLEV	Altamont		Pacheco Pass	
	SAN JOSE	SAN FRANCISCO	SAN JOSE	SAN FRANCISCO
Capital Cost (1)	\$3,427	\$6,423 (6)	\$5,549	\$8,540
Travel Time (Minutes)				
Express (2)	37	46	38	49
Local	60	79	38	71
From Sac. - Express	35	61	58	79
Length (Miles)	66	89	103	147
Ridership (3)	26.82/NA		28.06/6.4%	
Revenue (4)	\$999/NA		\$1,044/5.5%	
O&M Cost (5)	\$53	\$71	\$74	\$106

**Note:** (1) In Millions of 1999 Dollars  
(2) Travel times compared from Junction B to San Jose or San Francisco. Length and Capital Cost are compared from Junction A and B, respectively  
(3) In Millions of Annual Passengers for Statewide System/% Change from Baseline  
(4) In Millions Annually for Statewide System (1997 Dollars)/% Change from Baseline  
(5) In Millions Annually (1999 Dollars)  
(6) Capital Cost Includes Newark to San Jose segment

EXHIBIT 3-35  
BAY AREA ACCESS  
EVALUATION  
VHS/MAGLEV

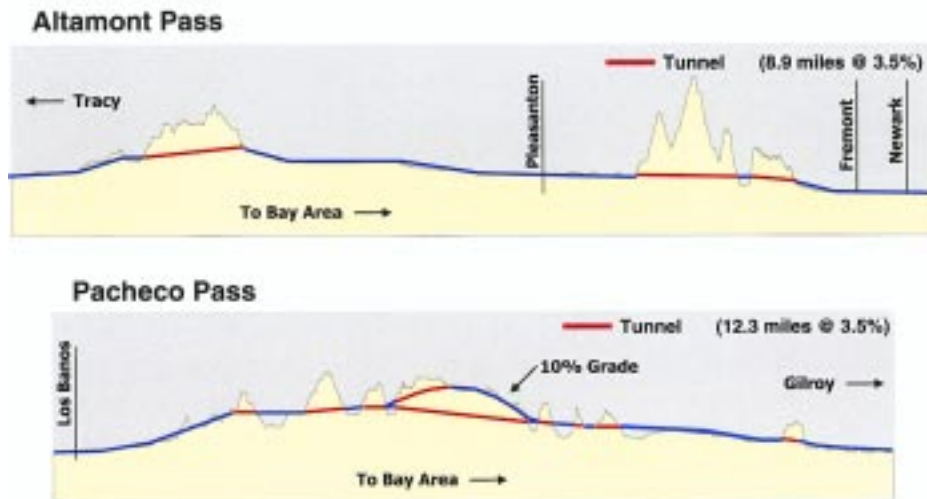


**EXHIBIT 3-36  
BAY AREA ACCESS  
EVALUATION  
KEY CONSTRAINTS/ISSUES**

Key Constraints / Issues*	
<b>Altamont</b>	
■ Requires branch operations	
■ Highest potential for T&E species impacts	
■ Major fault crossings	
■ Major floodplain encroachment - South Bay to San Jose	
<b>Pacheco Pass</b>	
■ Highest potential for visual impacts	
■ Highest potential for historic property impacts - San Jose	
■ Highest potential for parks and recreational impacts	
■ Highest potential for water resource impacts	

\* Key constraints and issues compiled from San Jose to Junctions A and B, respectively

**EXHIBIT 3-37  
BAY AREA ACCESS PROFILES**



tunneling than the Pacheco Pass, 8.9 miles as opposed to 12.3 miles (*Exhibit 3-37*). In addition, this alternative is 58 miles shorter in terms of joining the Central Valley alignment with the Bay Area. Since it is shorter and has fewer tunnels, the Altamont Pass is less costly than the Pacheco Pass.

Environmental issues associated with this corridor include substantial farmland impacts from south of Stockton to Tracy; impacts to threatened and endangered species such as California red-legged frog and the California clapper rail; crossing of the Stanislaus River and San Joaquin River in addition to other natural and channelized drainages; and potential direct or indirect impacts to historic properties in Tracy. HSR within this corridor also has the potential to affect low-income populations in Livermore and Pleasanton and minority populations in Manteca, Tracy, Pleasanton, Union City, and San Jose. There is also the potential for visual impacts to adjacent residences.

#### Pacheco Pass

This corridor turns west from the Central Valley alignment between Fresno and Merced. The more southerly location of this alternative leads to a Sacramento to San Francisco travel time of 1 hour and 48 minutes, which is not as competitive with other modes of travel compared to the Altamont Corridor alternative. This alternative does provide a faster travel time to San Jose from the south (e.g., Los Angeles), 10 minutes less than the Altamont option, and the time to San Francisco is only 3 minutes longer. Branch operations are not needed in this alternative to serve San Jose. Since they are along one line, the same train can serve San Jose and San Francisco, improving the level service to both destinations. Given the improved service and



**EXHIBIT 3-38**  
**BAY AREA ACCESS - REDUCED STATIONS**



	VHS	MAGLEV
	Reduced Stations	Reduced Stations
Capital Cost (1)	108	108
Travel Time (Minutes)		
Express	same	same
Local	-15	-13
Length (Miles)	NA	NA
Ridership (2)	19.19 / -4.1%	25.94 / -3.5%
Revenue (3)	\$659 / -4.3%	\$956 / -3.4%
O&M Cost (4)	NA	NA

**Note:** (1) In Millions of 1999 Dollars  
 (2) In Millions of Annual Passengers for Statewide System/% Change from Baseline  
 (3) In Millions Annually for Statewide System (1997 Dollars)/% Change from Baseline  
 (4) In Millions Annually (1999 Dollars)

competitive travel times to Southern California, the forecasted revenue for the Pacheco Pass is 8% higher for VHS service and 5.5% higher for Maglev service versus the Altamont Pass.

Overall, the Pacheco Pass option would have more negative environmental impacts as compared to Altamont Pass option. This option may potentially affect low-income populations in San Jose and minority populations in Gilroy, Morgan Hill, and San Jose. There would be substantially more water crossings associated with this alignment including over 20 small streams between the San Joaquin River and Los Banos. Farmland impacts are greatest within the area of Gilroy to Morgan Hill and Chowchilla to Los Banos. This option also has a high potential to directly or indirectly affect historic properties in Santa Clara. The San Luis Reservoir State Recreation Area and O'Neil Forebay may also be potentially affected by this option. There would be visual impacts to these resources as well as to residential areas adjacent to the alignment. Other environmental issues associated with this option include floodplain encroachment and potential impacts to threatened and endangered species.

### **Reduced Stations**

While the evaluation of the Bay Area Access alternatives included costing all of the potential stations, another alternative was studied reducing the number of stations on the line. The three stations to be eliminated in this alternative are Tracy, Newark/Fremont, and Redwood City. *Exhibit 3-38* illustrates the effect of not including these stations on the HSR line. Reducing the number of stations reduces capital costs by a relatively small amount (\$108 million) yet it reduces the ridership and revenue quite significantly. The express travel times would not be affected in this alternative, but the local travel times would improve by 15 minutes.

## Bay Area Alternatives

There were three primary alternatives in the Bay Area, (1) an alignment serving San Francisco via the peninsula, (2) an alignment serving Oakland via an east bay alignment, (3) both the peninsula and east bay corridors and (4) the potential for terminating the HSR line before the urban centers at an interface with existing regional transit (*Exhibit 3-49 and 3-41*). In addition, there are alternative sites for the downtown termini in San Francisco and Oakland, which are presented.

The evaluation of the peninsula and east bay corridors as accessed by the Altamont Pass is presented in *Exhibit 3-40* for VHS and Meglev. The capital cost presented in these figures is the cost from Newark to downtown San Francisco (Transbay Terminal) or from Newark to West Oakland. The evaluation of the alterna-

**EXHIBIT 3-39**  
**BAY AREA - ALTAMONT ACCESS**



**EXHIBIT 3-40**  
**BAY AREA VIA ALTAMONT EVALUATION - VHS/MAGLEV**

VHS	SF via Peninsula (1)	Oakland via East Bay (1)
Capital Cost (2)	\$2,576	\$1,566
Travel Time (Minutes)		
Express	23	15
Length (Miles)	38	26
Ridership (3)	20.02/NA	18.95/-5.3%
Revenue (4)	\$688/NA	\$657/-4.6%
O&M Cost (5)	\$19	\$13
Key Constraints/Issues	■ Bay Crossing Required	

MAGLEV	SF via Peninsula (1)	Oakland via East Bay (1)
Capital Cost (2)	\$2,996	\$1,891
Travel Time (Minutes)		
Express	18	12
Length (Miles)	38	26
Ridership (3)	26.87/NA	25.66/-4.5%
Revenue (4)	\$990/NA	\$953/-3.7%
O&M Cost (5)	\$19	\$13
Key Constraints/Issues	■ Bay Crossing Required ■ Highly Constrained ROW	

**Note:** (1) Alternatives from Newark to San Francisco or Oakland. Does not include Newark to San Jose.  
 (2) In Millions of 1999 Dollars  
 (3) In Millions of Annual Passengers for Statewide System/% Change from Baseline  
 (4) In Millions Annually for Statewide System (1997 Dollars)/% Change from Baseline  
 (5) In Millions Annually (1999 Dollars)





tives for the Bay Area if accessed by the Pacheco Pass is presented in *Exhibit 3-42*. The capital costs are presented from San Jose to the Transbay Terminal and from San Jose to West Oakland. Key constraints and issues for peninsula versus east bay corridors are summarized in *Exhibit 3-43*.

**EXHIBIT 3-41  
BAY AREA PACHECO ACCESS**



**EXHIBIT 3-42  
BAY AREA VIA PACHECO EVALUATION - VHS/MAGLEV**

VHS	Peninsula (1)	East Bay (1)	Both (1)
Capital Cost (2)	\$2,888	\$1,977	\$4,865
Travel Time (Minutes)			
Express	28	24	NA
Length (Miles)	49	43	NA
Ridership (3)	21.12/+5.5%	20.49/+2.3%	21.10/+5.4%
Revenue (4)	\$744/+8.0%	\$725/+5.2%	\$746/+8.4%
O&M Cost (5)	\$34	\$30	\$64

MAGLEV	Peninsula (1)	East Bay (1)	Both (1)
Capital Cost (2)	\$2,888	\$1,977	\$4,865
Travel Time (Minutes)			
Express	28	24	NA
Length (Miles)	49	43	NA
Ridership (3)	21.12/+5.5%	20.49/+2.3%	21.10/+5.4%
Revenue (4)	\$744/+8.0%	\$725/+5.2%	\$746/+8.4%
O&M Cost (5)	\$34	\$30	\$64

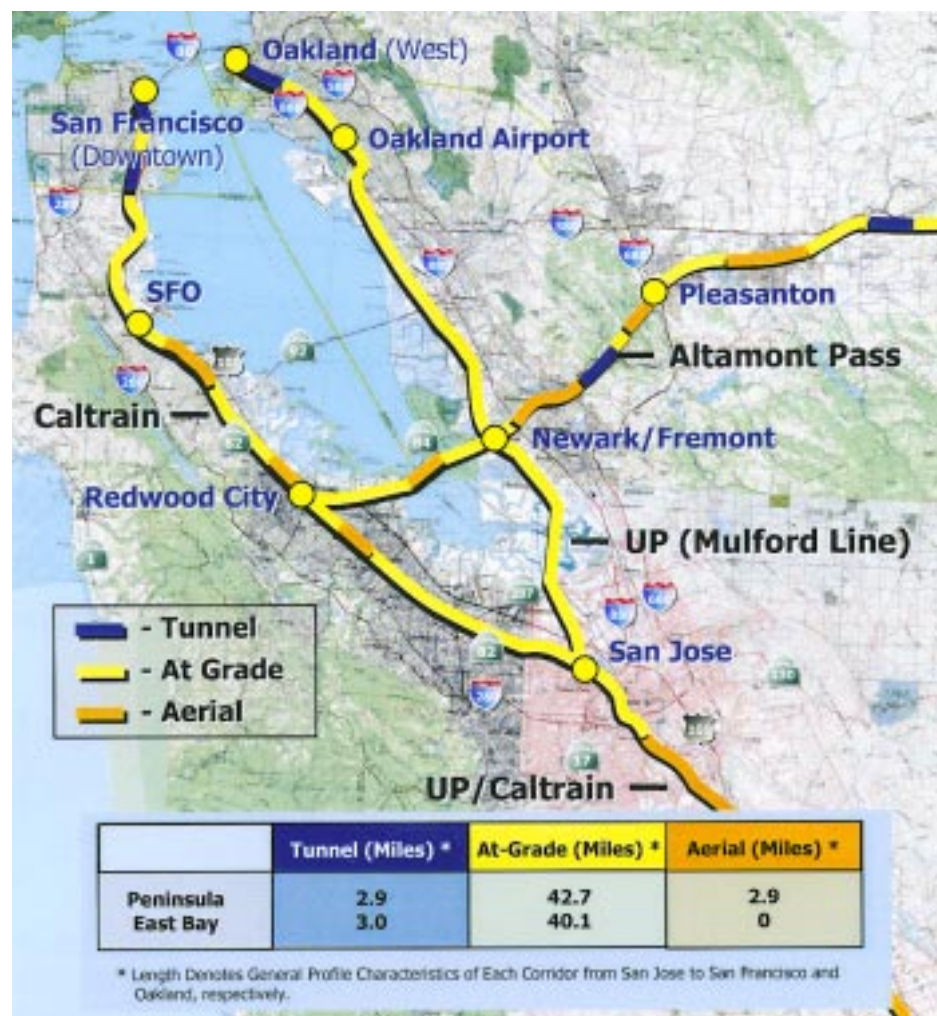
**Note:** (1) Alternatives from San Jose to San Francisco or Oakland.  
(2) In Millions of 1999 Dollars  
(3) In Millions of Annual Passengers for Statewide System/% Change from Baseline  
(4) In Millions Annually for Statewide System (1997 Dollars)/% Change from Baseline  
(5) In Millions Annually (1999 Dollars)

**EXHIBIT 3-43  
BAY AREA - KEY CONSTRAINTS/ISSUES**

Key Constraints / Issues
<b>Peninsula</b>
<ul style="list-style-type: none"> <li>■ Highly constrained R/W corridor</li> <li>■ Existing services (Caltrain and freight)</li> <li>■ Highest potential for historic property impacts</li> <li>■ Highest potential for visual impacts</li> </ul>
<b>East Bay</b>
<ul style="list-style-type: none"> <li>■ Constrained R/W corridor</li> <li>■ Existing services (freight)</li> <li>■ Highest potential for T&amp;E species impacts</li> <li>■ Highest potential for Hazardous Material/Waste sites</li> </ul>

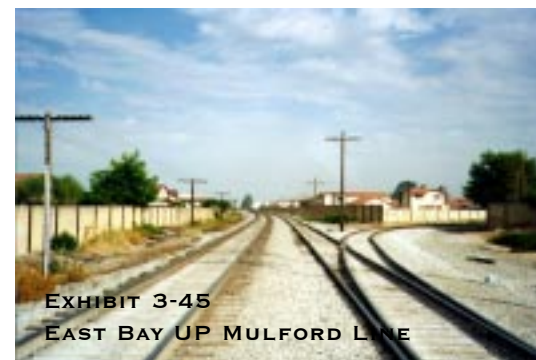


**EXHIBIT 3-44**  
**BAY AREA PROFILE CHARACTERISTICS**



### East Bay

The alignment through the East Bay area follows the UP Mulford line. The HSR tracks would be constructed at-grade and adjacent to the existing tracks wherever possible. There is relatively less development (commercial and industrial users) along the East Bay (*Exhibit 3-45 and 3-46*), which makes it possible to keep the HSR tracks at-grade until reaching downtown Oakland (*Exhibit 3-44*). The dense development in downtown Oakland along Jack London Square necessitates placing the HSR tracks in tunnel, since the visual impacts of an elevated guideway are considered unacceptable due to the historic value of this area.



**EXHIBIT 3-45**  
**EAST BAY UP MULFORD LINE**



**EXHIBIT 3-46**  
**EAST BAY UP MULFORD LINE**



While the overall environmental impacts of this corridor are not as severe as the Peninsula corridor, the impacts would still be substantial. Environmental issues associated with this corridor include visual quality, historic properties, parks and recreation areas, and hazardous materials/waste sites. This corridor has the potential to affect low-income populations in San Carlos, San Lazerno, and Oakland and minority populations in San Jose, Milpitas, Hayward, San Leandro, and Oakland. There also are numerous water crossings associated with this corridor, as well as impacts to threatened and endangered species including the salt-marsh harvest mouse.

#### Peninsula

The peninsula corridor is heavily constrained by commercial and residential development and availability right of way (*Exhibit 3-47 and 3-48*). The existing Caltrain corridor ends at 4<sup>th</sup> and Townsend in San Francisco. If the HSR line terminus is at the Transbay Terminal, extremely dense development in Downtown requires the use of a tunnel extending from the existing terminus. Included in the cost of the peninsula corridor is the construction of a new San Francisco Bay crossing. The east bay alignment is shorter than the

peninsula alignment, which leads to faster travel times. Due to the length and less development, the capital cost for the east bay corridor is lower as well.

However, San Francisco is more often the destination for HSR passengers. Therefore, an Oakland terminus without service to the peninsula results in lower ridership and revenue. The potential for serving both sides of the bay was not addressed for the Altamont Pass access because this would require operating three branches, which is too great a negative impact on service.

As stated above, the environmental impacts of this corridor would be greater than the East Bay corridor. This is mainly due to the dense development up the peninsula. HSR improvements within this corridor may potentially affect low-income populations in San Mateo and San Francisco, and minority populations in San Jose, Mountain View, Palo Alto, Millbrae, San Bruno and San Francisco.

There are many historic properties adjacent to this corridor including many in downtown San Francisco. Given the density of development and adjacent scenic resources, visual impacts would be significant. Other issues associated with this corridor include threatened and endangered

species including the California tiger salamander; hazardous materials/waste sites; and parks and recreational resources.



**EXHIBIT 3-49**  
**BAY AREA TERMINUS OPTIONS**



Both Peninsula and East Bay Corridors

The potential for serving both sides of the bay is also addressed for the Pacheco Pass assess (*Exhibit 3-42*). If service were offered to both the east bay and the peninsula, every train would still serve San Jose but the frequency of service to the two termini would be diminished. As a result, the ridership and revenue for serving both termini is only slightly higher than if service is only offered to the peninsula. The forecasted ridership and revenue are higher for the Pacheco Pass alternative than for the Altamont Pass access. This is the result of faster travel times to San Jose and improved frequency of service to San Jose and to the termini, either San Francisco or Oakland.





### Terminus at Interface with Regional Transportation System

Several specific scenarios (*Exhibit 3-49 and 3-51*) for terminating the HSR line before the urban centers are presented in (*Exhibit 3-50 and 3-52*). The first of these options is to place the terminus at 4<sup>th</sup> and Townsend in San Francisco, the current Caltrain terminus and connect with existing bus transit and MUNI light rail transit services. This saves approximately \$270 million and only decreases ridership and revenue slightly. This also eliminates the need for tunneling under downtown San Francisco to reach the Transbay terminal. The sec-

ond option is to place the HSR terminus at the SFO station, which would allow HSR passengers to connect to either air transportation or to Caltrain and BART. Other options for terminal locations included San Jose and Pleasanton.

For the east bay, terminus options include the Lake Merritt BART Station and the Oakland airport. The Lake Merritt option saves over \$420 million and eliminates the need to tunnel under Jack London Square. HSR passengers could transfer to the BART system to reach other Bay Area destinations. Terminating the HSR line at Oakland airport saves over \$920 million in capital costs while passengers will be able to transfer to the airport or BART system.

**EXHIBIT 3-50**  
**BAY AREA TERMINUS OPTIONS EVALUATION**  
**VHS/MAGLEV**

Net Savings, if Terminated at:

VHS	4th & Townsend (1)	SFO (1)	San Jose (1)		Pleasanton (1)
			Altamont (6)	Pacheco	
Capital Cost (2)	-\$269	-\$1,298	-\$2,576	-\$2,888	-\$4,009
Travel Time (Minutes) Express	-2	-11	-23	-28	-28
Length (Miles)	-1	-14	-38	-49	-51
Ridership (3)	19.91/-0.5%	18.50/-7.6%	17.44/-12.9%	16.66/-16.8%	15.72/-21.5%
Revenue (4)	\$684/-0.6%	\$631/-8.3%	\$590/-14.4%	\$565/-18.0%	\$528/-23.2%
O&M Cost (5)	-\$1	-\$7	-\$19	-\$34	-\$32

Net Savings, if Terminated at:

MAGLEV	4th & Townsend (1)	SFO (1)	San Jose (1)		Pleasanton (1)
			Altamont (6)	Pacheco	
Capital Cost (2)	-\$276	-\$1,466	-\$2,996	-\$3,395	-\$4,551
Travel Time (Minutes) Express	-1	-8	-18	-22	-22
Length (Miles)	-1	-14	-38	-49	-51
Ridership (3)	26.73/-0.5%	24.76/-7.8%	23.21/-13.6%	21.59/-19.7%	21.00/-21.8%
Revenue (4)	\$984/-0.6%	\$903/-8.8%	\$839/-15.3%	\$771/-22.1%	\$752/-24%
O&M Cost (5)	-\$1	-\$7	-\$19	-\$35	-\$33

**Note:** (1) Terminus Option versus Downtown San Francisco  
(2) Net Cost Savings in Millions of 1999 Dollars  
(3) In Millions of Annual Passengers for Statewide System/% Change from Baseline  
(4) In Millions Annually for Statewide System (1997 Dollars)/% Change from Baseline  
(5) In Millions Annually (1999 Dollars)  
(6) Net Savings from Newark to Downtown San Francisco



**EXHIBIT 3-51**  
**BAY AREA TERMINUS OPTIONS (EAST BAY)**



**EXHIBIT 3-52**  
**BAY AREA TERMINUS OPTIONS (EAST BAY)**  
**EVALUATION - VHS/MAGLEV**

	VHS	MAGLEV
	Lake Merritt (1)	Lake Merritt (1)
Capital Cost (2)	-\$424	-\$437
Travel Time (Minutes)		
Express	-2	-1
Length (Miles)	-2	-2
Ridership (3)	NA	NA
Revenue (4)	NA	NA
O&M Cost (5)	-\$1	-\$1

	Coliseum/Airport (1)	Coliseum/Airport (1)
Capital Cost (2)	-\$921	-\$1,001
Travel Time (Minutes)		
Express	-6	-5
Length (Miles)	-7	-7
Ridership (3)	NA	NA
Revenue (4)	NA	NA
O&M Cost (5)	-\$4	-\$4

**Notes:** (1) Terminus Option versus Downtown San Francisco  
(2) Net Cost Savings in Millions of 1999 Dollars  
(3) In Millions of Annual Passengers for Statewide System/%  
Change from Baseline  
(4) In Millions Annually for Statewide System (1997 Dollars)/%  
Change from Baseline  
(5) In Millions Annually (1999 Dollars)



### 3.4 LOSSAN CORRIDOR

The evaluation of the LOSSAN corridor is presented separately in this section because it was analyzed based on two key assumptions that differ from those outlined in Chapter 2 and applied to the corridors addressed in Sections 3.2 – 3.3 of this Chapter. Given the high level of existing passenger rail service and extensive existing rail infrastructure on this corridor, key assumptions were made regarding the application of mixed traffic operations and incremental improvement phasing. For this alternative, improvements would be made to the existing LOSSAN rail corridor and rail service to improve this service as a link to the HSR corridor in Los Angeles with the potential for eventual VHS service along the line. These improvements could be applied with or without the implementation of an inland (I-15) corridor.

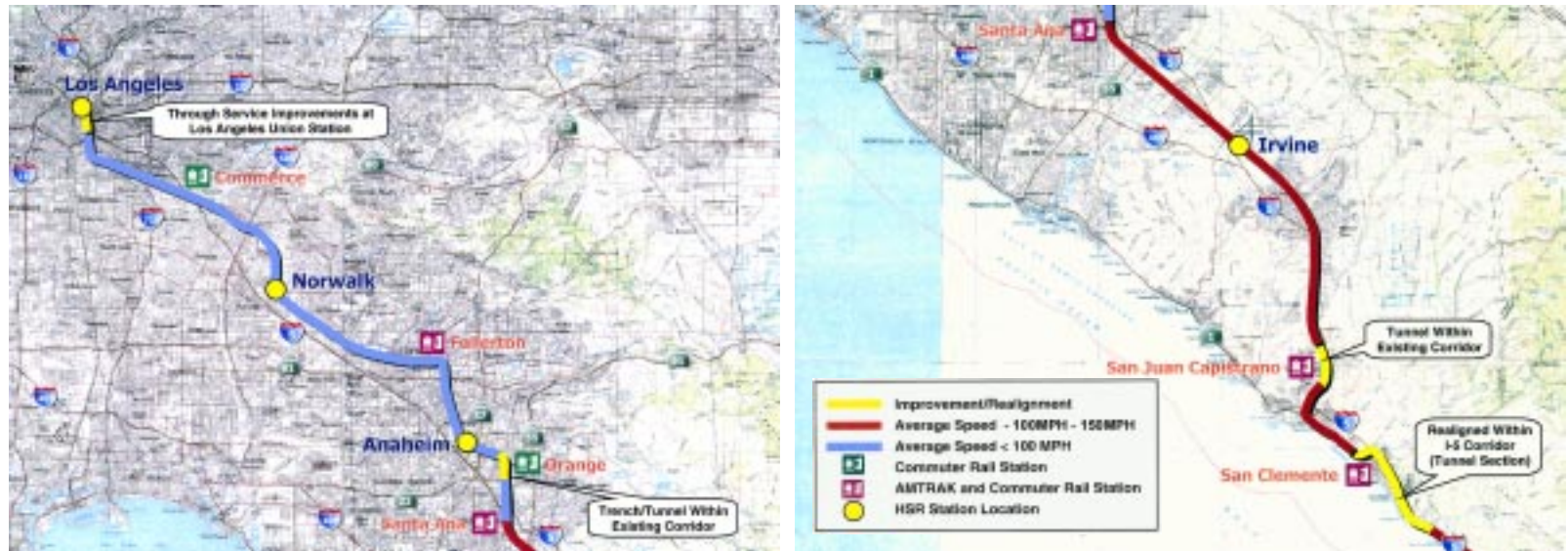
#### Improvement Concept

The existing LOSSAN corridor is the second most traveled rail passenger route in the United States. In addition to Amtrak's intercity service, there are also two thriving commuter rail services (Metrolink and Coaster) operating on this corridor, as well as a significant amount of freight traffic. Although the corridor provides the most direct rail route between Los Angeles and San Diego, it passes through some of the state's most populated regions and environmentally sensitive areas (e.g., wetlands and coastal communities). A variety of improvements are identified in this alternative to meet the following objectives:

- Maximize the use of existing infrastructure and rights of way,
- Minimize environmental impacts (e.g., noise, wetland intrusion, etc.) in sensitive areas,
- Resolve/mitigate existing environmental issues and concerns,
- Maximize the safety, capacity and reliability of rail passenger service in this corridor, and
- Minimize the travel times for all passenger rail services in this corridor.

#### EXHIBIT 3-53

#### LOSSAN CORRIDOR IMPROVEMENTS



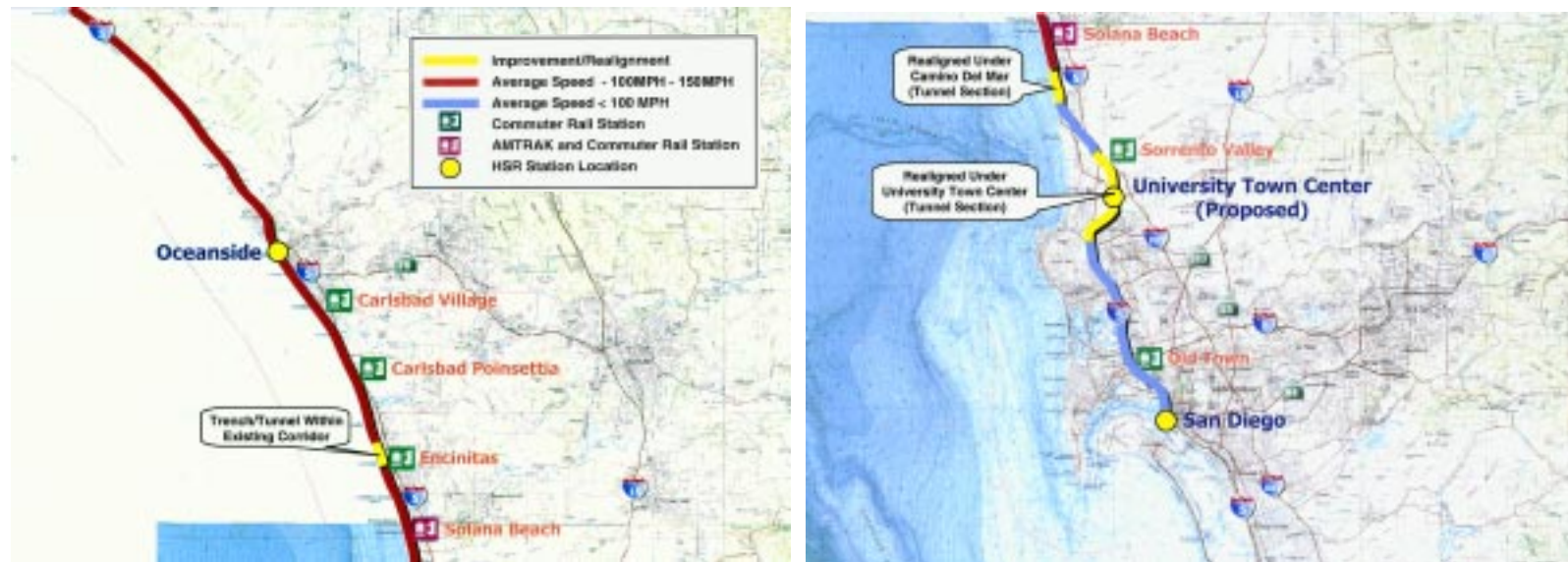
Improvements meeting these objectives could be implemented incrementally, building upon projects currently under construction or programmed. Each grade separation or double tracking project will provide increased benefits to the existing services as well as allowing for the addition of new faster, quieter services. In addition, electrification of the corridor would provide both environmental (reduction in noise and air pollution) and operational (decreased travel times) benefits. However, until the compatibility issues of the very high speed rail rolling stock is addressed, all services would require a transfer at Los Angeles Union Station to board the statewide very high speed rail service. Ultimately, with compatibility issues addressed, VHS service could be provided on this corridor, thus, providing service in addition to or instead of the inland route.

This improvement concept includes improving conventional service (i.e. faster travel times and increased service) along with the option of direct VHS service. Achieving faster travel times with conventional trains may require purchasing new locomotives, either diesel or electric. The cost of these locomotives as well as the cost of additional trainsets for increasing service is not included in the estimate. Contrary to the assump-

tion made for the other corridors, in this alternative the VHS trains would utilize the same tracks as the conventional passenger trains. Allowing for mixed traffic operations along the corridor could also improve existing service and would be necessary if VHS trains are to share the tracks. Electrification of the corridor is also necessary for VHS service but could additionally benefit conventional service (i.e. improved performance of electric locomotives).

Other features of this alternative include creating a fully grade separated double track system. At stations, off line station-stopping tracks would be provided to allow for through service. Signaling improvements would be made to increase the safety and capacity of the corridor as well as allow for increased operating speeds.

**EXHIBIT 3-53**  
**LOSSAN CORRIDOR IMPROVEMENTS**







In addition to these overall improvements, specific improvements would be made at key constrained locations along the corridor (*Exhibit 3-53*). At Los Angeles Union Station, “run through” tracks would be created. Through Santa Ana/Orange, a trench/tunnel segment in south Orange would permit through service and reduce ongoing noise and traffic impacts on the neighboring community. In San Juan Capistrano, a short tunnel segment under the existing station would permit through service. Through San Clemente, a new tunnel alignment under I-5 would bypass the current beach alignment, improving both safety and service. In Encinitas, a short tunnel under the existing station would allow for through service. In Del Mar, a tunnel alignment under Camino Del Mar would bypass the current beach alignment. At Rose Canyon, a bypass tunnel would run under the University Town Center area.

For conventional service, all of the existing and planned stations could be utilized. For VHS service, station stops would be limited to provide faster service. Potential stations considered for VHS service include Norwalk, Anaheim, Irvine, Oceanside, University Town Center, San Diego Airport and Downtown San Diego.

The proposed improvement concept allows for significant increases in operating speeds and reliability. Assumed average operating speeds are illustrated in general in *Exhibit 3-53*. Travel times are reduced significantly (approximately one-half of times for existing services) as presented in *Exhibit 3-54*.

### Corridor Evaluation

The evaluation of the LOSSAN corridor improvements is presented in (*Exhibit 3-55*). The cost of improving the LOSSAN corridor so that it is VHS service compatible is \$2.81 billion, as opposed to \$4.0 billion for constructing the inland corridor from Riverside to San Diego. The cost of electrification comprises \$317 million of the total cost of the LOSSAN improvements. In comparing the LOSSAN corridor to the Inland Corridor between Los Angeles and San Diego, the LOSSAN corridor is approximately 40 miles shorter than the inland corridor and is 7 minutes faster for a VHS express trip. For Orange County, this option provides the most complete service as compared to the other alternatives, since the corridor serves a larger segment of the County with the greatest number of stations. This option also benefits the county by mitigating many of the existing problems within the corridor

**EXHIBIT 3-54**  
**LOSSAN CORRIDOR IMPROVEMENTS**

	LOSSAN Corridor
Capital Cost (1)	
with Electrification	2,813
without Electrification	2,496
Travel Times (Minutes)	
Existing (Amtrak)	151
Proposed HSR Express	61
Proposed HSR Local (2)	83
Length (Miles)	129
Ridership (3)	23,136 / 1.8%
Revenue (4)	\$804 / 1.5%
O&M Cost (5)	NA

(1) In Millions of 1999 Dollars  
(2) Assumes Stops at Los Angeles, Norwalk, Anaheim, Irvine, Oceanside, University Town Center and San Diego  
(3) In Millions of Annual Passengers for Statewide System's % Change from Staff Recommended System including Inland Corridor (Riverside to San Diego), excluding LOSSAN Corridor.  
(4) In Millions Annually for Statewide System (1997 Dollars) / % Change from Staff Recommended System including Inland Corridor (Riverside to San Diego), excluding LOSSAN Corridor.  
(5) In Millions Annually (1999 Dollars)

There are several issues associated with improvement of the LOSSAN corridor that need to be addressed as the concept is further developed. Until VHS service could be implemented, HSR passengers traveling to or from San Diego would then be required to transfer at LA Union Station. Furthermore, allowing VHS trains to share the tracks would require approval from the FRA for mixed traffic operations (see discussion under Chapter 2 - Compatibility Issues). Although these improvements are designed to mitigate the corridor's impact on surrounding communities, increasing the number of trains through the corridor would result in increased noise levels and overhead wiring for train electrification would result in visual quality impacts. In addition, the LOSSAN corridor extends through densely populated areas and through sensitive habitats along coastal areas and would be subject to rigorous public and agency review.



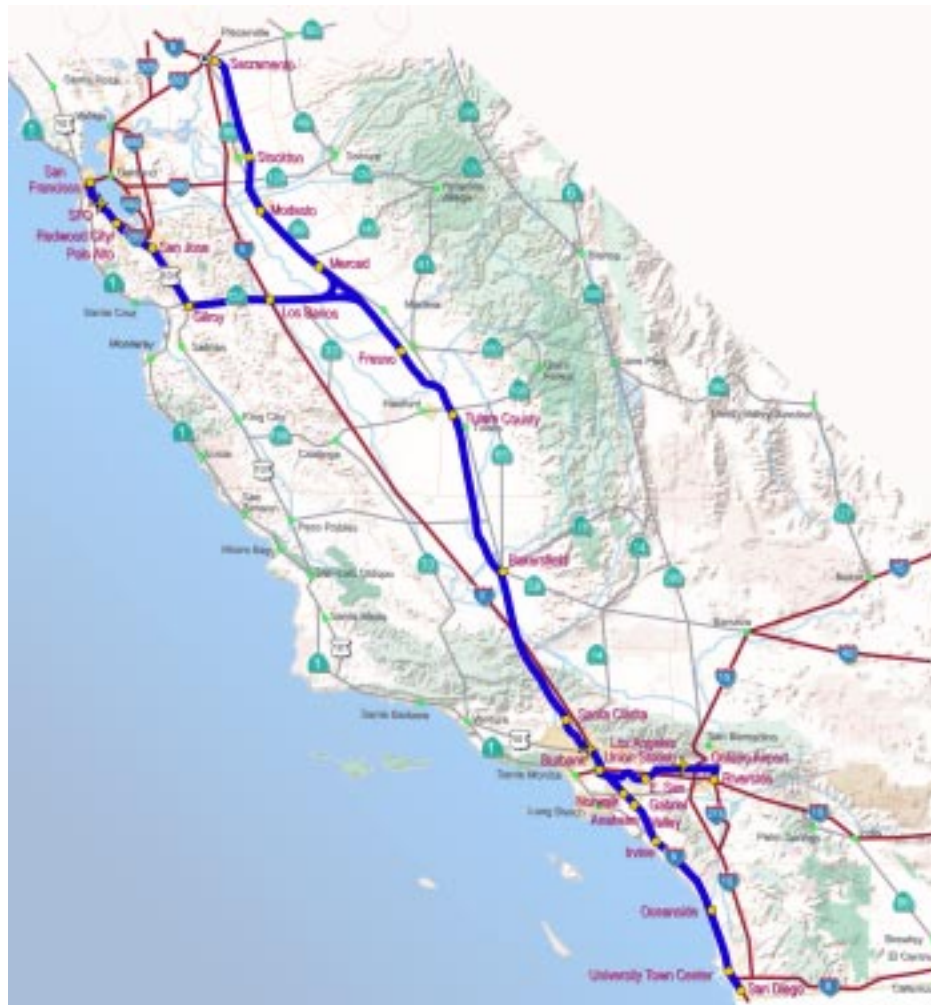
# OVERALL CORRIDOR COMPARISON

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# IV - OVERALL CORRIDOR COMPARISON

EXHIBIT 4-1  
STAFF RECOMMENDED CORRIDOR MAP



Based on the regional analyses, three statewide alignments were developed according to the recommendations of the Authority and Authority staff. These corridors utilize the various regional segments to create a system serving all of the state's major population centers. Each of the three alternatives are described below in terms of alignment and compared in terms of capital and operating cost and travel times similarly to the regional alternatives.

## 4.1 ALTERNATIVE DEFINITION

### Staff Recommended Corridor

The Staff Recommended Corridor (*Exhibit 4-1*) utilizes an incrementally improved LOSSAN corridor to connect Los Angeles and San Diego, the Riverside Terminus Branch to serve the Inland Empire and the Grapevine Pass alternative to cross the Tehachapi Mountains. Through the Central Valley, this option uses the West 99 corridor with the Pacheco Pass corridor to connect the Central Valley with the Bay Area. In the Bay Area, only the Peninsula alternative is used with a San Francisco terminus at 4<sup>th</sup> and Townsend. Finally, a branch extends the beginning of the Pacheco branch line (south of Merced) along the West of 99 corridor alternative to Modesto and then to the east of SR 99 through Stockton to Sacramento.

Since the LOSSAN corridor is proposed in this alternative to be incrementally improved as a rail corridor, the use of Maglev technology or any other portion of this alternative would require a transfer at Union Station for service to San Diego.



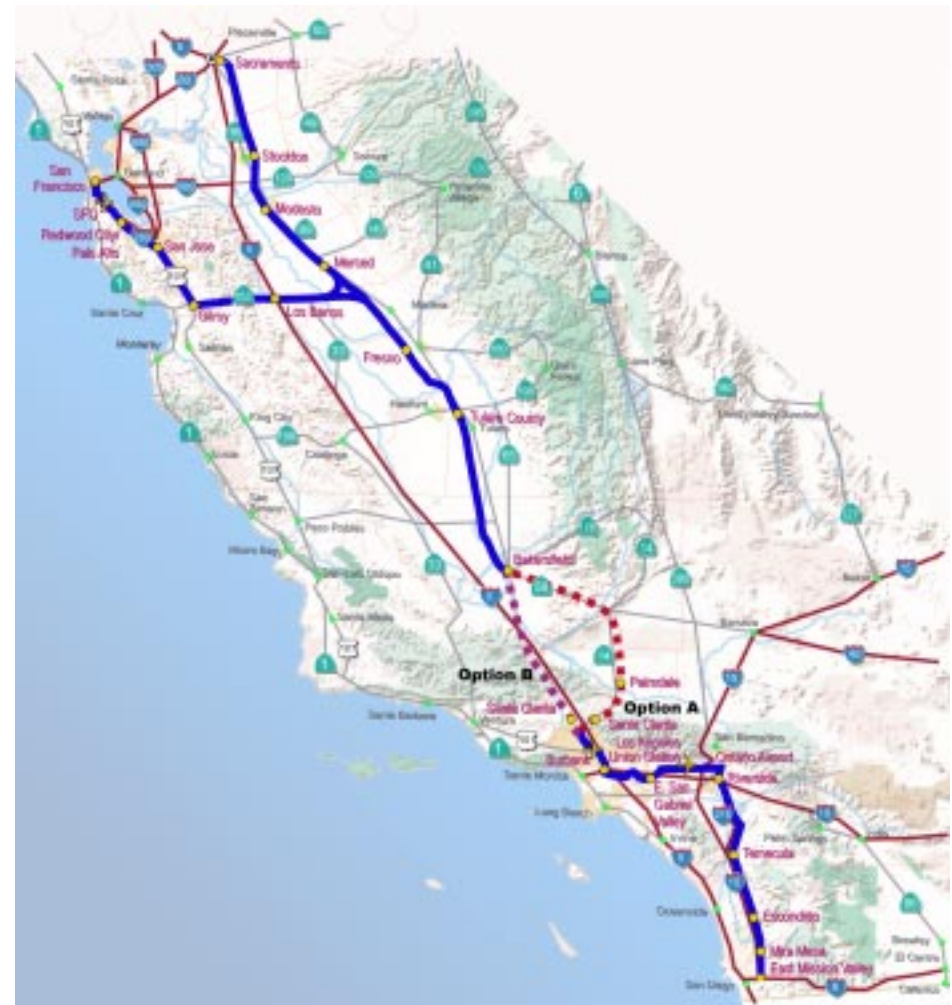
### Authority Option A

To the south, the Inland Corridor connects Los Angeles and San Diego, with the San Diego terminus at Qualcomm Stadium (*Exhibit 4-2*). This option therefore serves the Inland Empire but does not serve Orange County. The Antelope Valley/Mojave Pass alternative is utilized for the Tehachapi crossing. For the Central Valley and Northern California regions, this option is the same as the Staff Recommended Corridor.

### Authority Option B

This corridor is the same as the Authority Option A (*Exhibit 4-2*) corridor with the exception of the Tehachapi Mountain crossing. Authority Option B utilizes the Grapevine Pass rather than the Antelope Valley alternative.

EXHIBIT 4-2  
AUTHORITY RECOMMENDED CORRIDORS MAP



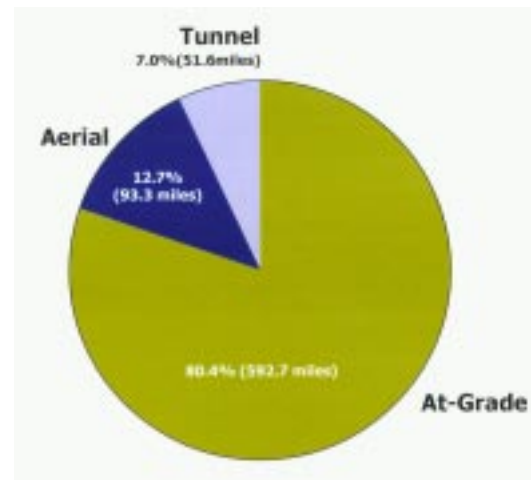
## 4.2 ALTERNATIVE COMPARISON

North of Bakersfield all three alternatives are the same. The differences in the options are in the area of the Tehachapi Crossing (I-5/Grapevine versus Palmdale-Mojave) and the San Diego Region (LOSSAN versus the Inland Route).

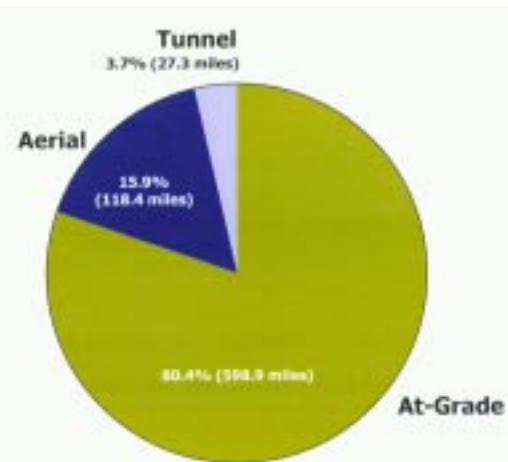
### Profile Comparison

The composition of the three routes in terms of cross-section (or type of construction) is compared in *Exhibits 4-3, 4-4, 4-5*. While the differences appear to be minor relative to the overall proportions, it should be noted that in terms of actual quantities they are significant. For example, the Staff Recommended System has 25 more miles of tunneling than Authority Option A. In general, the length of the alternative and the proportion of these cross-section types are the primary determinant of capital cost.

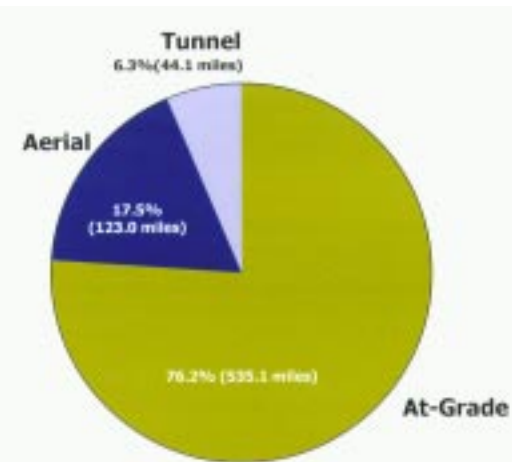
**EXHIBIT 4-3  
PROFILE COMPARISON  
STAFF RECOMMENDED**



**EXHIBIT 4-4  
PROFILE COMPARISON  
OPTION A**



**EXHIBIT 4-5  
PROFILE COMPARISON  
OPTION B**







## Capital Cost

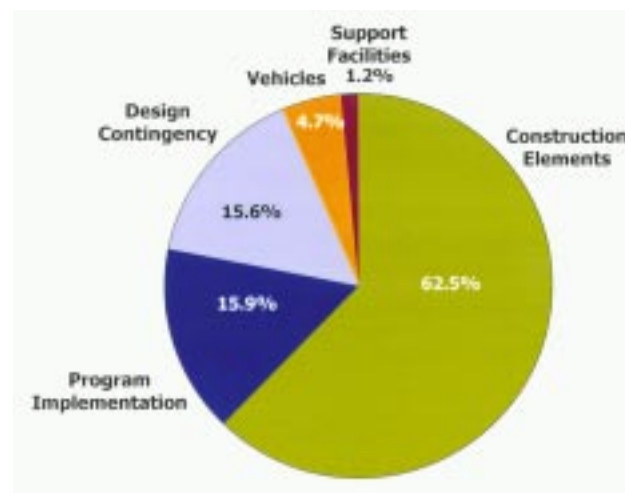
The total capital cost for these alternatives ranges from \$23.8 to 25.7 billion for a VHS system and \$34.2 billion for a Maglev system as shown in *Exhibit 4-6*. This total cost is comprised of the construction elements (infrastructure), the vehicles and support facilities, the contingencies and the agency costs for implementation. Of course the construction elements represent the majority of the cost followed by the costs associated with implementation. The example breakdown of this total cost into construction elements, vehicles, etc. is shown in *Exhibit 4-7* which is for Option B.

**EXHIBIT 4-6**  
**CAPITAL COST SUMMARY**

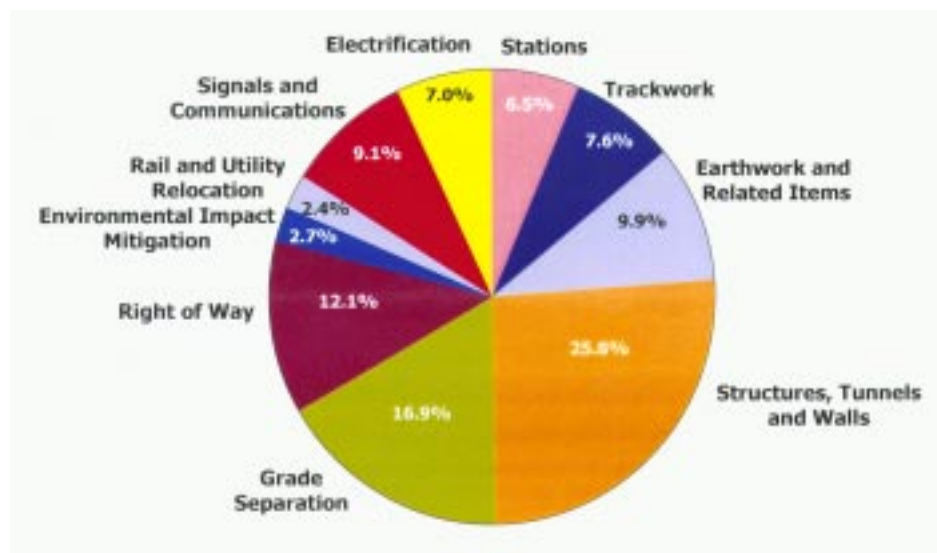
Segment	Capital Cost <sup>1)</sup>			
	Staff Recommended (VHS)	Authority Option A (VHS)	Authority Option A (Maglev)	Authority Option B (VHS)
San Diego - Los Angeles	\$2,813	\$6,765	\$8,364	\$6,765
Riverside - Los Angeles	2,761	NA	NA	NA
Los Angeles - Bakersfield	4,441	5,169	6,876	4,441
Bakersfield - Stockton	3,427	3,385	6,067	3,427
Stockton - Sacramento	1,880	1,880	2,559	1,880
Merced - San Jose	4,485	4,485	5,904	4,485
San Jose - San Francisco	2,494	2,494	2,970	2,494
<b>Subtotal</b>	<b>\$22,301</b>	<b>\$24,178</b>	<b>\$32,740</b>	<b>\$23,492</b>
Vehicles and Support Facilities	1,482	1,482	1,420	1,482
<b>Total</b>	<b>\$23,783</b>	<b>\$25,660</b>	<b>\$34,160</b>	<b>\$24,974</b>

1) In millions of 1999 dollars

**EXHIBIT 4-7**  
**TOTAL COST BREAKDOWN - OPTION B**



**EXHIBIT 4-8**  
**CONSTRUCTION COST BREAKDOWN - OPTION B**



The breakdown for the cost of the different construction elements is presented in *Exhibit 4-8*, using option B as an example. The costs of structures, tunnels and walls comprise the largest portion of the construction costs, followed by grade separations and right of way. While the construction costs of infrastructure related items are relatively stable and predictable, right of way costs are less so. Moreover, the availability of right of way in specific corridors will rapidly decrease as development occurs throughout the state.

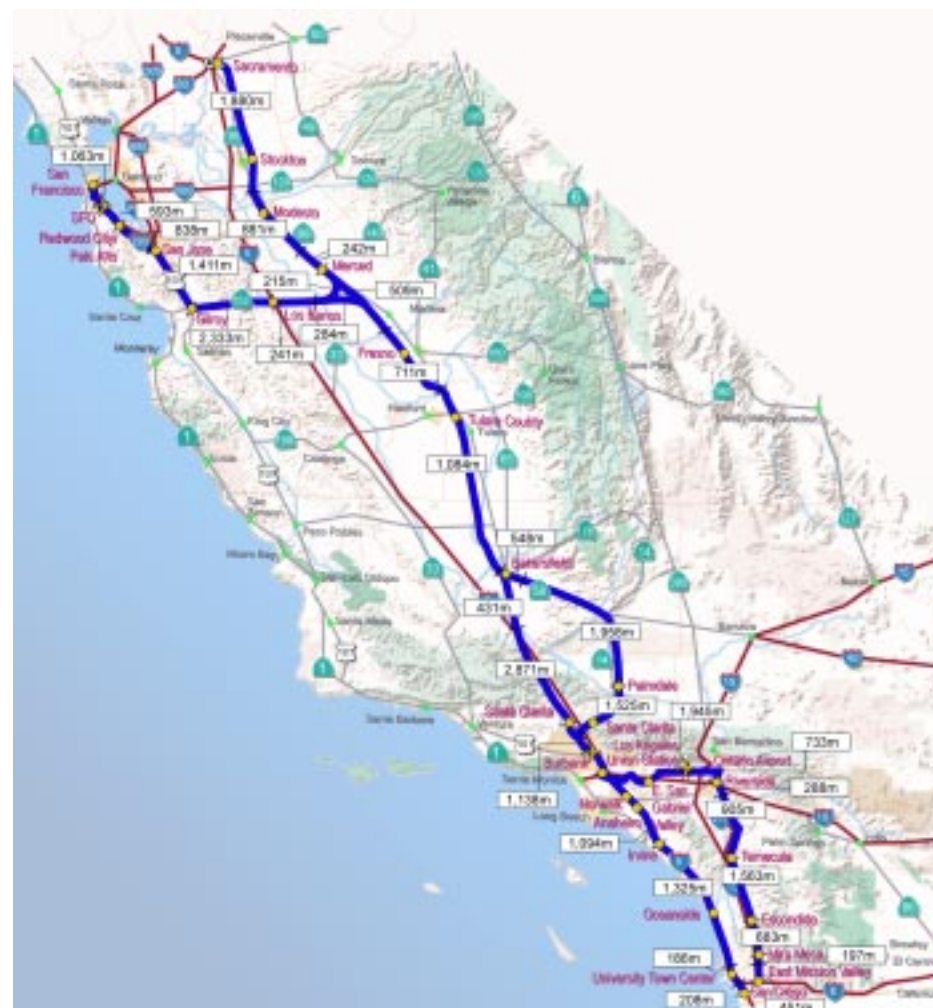
**EXHIBIT 4-9**  
**CORRIDOR COMPARISON SUMMARY**

	Staff Recommended (VHS)	Authority Option A (VHS)	Authority Option A (Maglev)	Authority Option B (VHS)
<b>Length (miles):</b>	738	744	744	703
At-Grade	593	599	599	536
Aerial	93	118	118	123
Tunnel	52	27	27	44
<b>Capital Cost (millions)<sup>1</sup></b>	\$23,783	\$25,660	\$34,160	\$24,974
<b>Travel Times (hours:minutes)</b>				
Los Angeles - San Francisco	2:30	2:42	2:00	2:30
Los Angeles - San Diego	1:03	1:00	0:49	1:00
Los Angeles - Sacramento	2:09	2:20	1:40	2:09
Los Angeles - San Jose	2:02	2:13	1:37	2:02
<b>Operations and Maintenance</b>				
Annual Train Miles (millions)	23.7	26.1	26.1	24.3
Annual O&M Costs (millions)	\$538	\$593	\$579	\$551

<sup>1</sup>) 1999 dollars



The total capital costs are shown for each alternative by major geographical segment in *Exhibit 4-6* for reference on a regional basis. For estimating capital costs, the alignments are broken down into smaller costing segments. The cost for each segment for all alternatives and technologies is shown in *Exhibits 4-10 and 4-11*.









**EXHIBIT 4-12**  
**COST/MILE - VHS**

The capital cost per mile varies by technology, terrain and land development (*Exhibits 4-12 and 4-13*). For VHS technology, the cost per mile ranges from a low of \$13 million per mile in the least developed regions to over \$80 million per mile in the dense urban areas. The average cost per mile for suburban areas is \$45 million per mile and for regions of mountainous terrain \$50 million per mile. For Maglev technology, the cost per mile ranges from a low of \$25 million per mile in the undeveloped areas and over \$90 million per mile in dense urban regions. The average cost per mile for suburban areas is \$55 million per mile and for regions of mountainous terrain \$60 million per mile.







## Operations and Maintenance Costs

The operations and maintenance costs for all of the statewide corridors are presented in *Exhibit 4-6*. The annual O&M costs range from \$538 to \$593 for the alternatives with the VHS technology and slightly less with the Maglev technology.

These costs are comprised of the costs of train operations, equipment maintenance, maintenance of way, station services, marketing/reservations, insurance, general support and power. Train operations, equipment maintenance, maintenance of way and power are the largest elements by proportion of the total costs.

For reference, it is interesting to consider the energy usage of the HSR system in terms of an example trip. A very high-speed train (steel-wheel-on-steel-rail) would require approximately 16,000 kilowatt-hours to travel between Los Angeles and San Francisco (approximately 400 miles). A Maglev train would require approximately 19,500 kilowatt-hours for the same trip. Based on an average price of \$0.11 per kilowatt-hour and a passenger per train load factor of 70%, the energy costs per passenger will be approximately \$3.87 for the steel wheel technology and \$4.71 for Maglev (that is approximately \$0.01/passenger/mile). Power costs represent approximately 13 –15% of the total operating and maintenance cost of the system, depending on technology.

## Travel Times

*Exhibit 4-14* presents express travel times between several key city pairs for each of the alignment and technology options. In addition, travel times matrices showing every station for both local and express service are in *Appendix I*. The local travel times for each technology from station to station as well as the average local service speed are shown in *Exhibits 4-15 and 4-16* while the average express speed is shown in *Exhibit 4-17 and 4-18*.

The primary difference between the travel times in these three alternatives is in the express trip between Los Angeles and San Francisco which varies by approximately 12 minutes depending on whether the I-5/Grapevine or Palmdale-Mojave Tehachapi Crossing is used. Distances from station to station are shown in *Exhibit 4-19*.

**EXHIBIT 4-14**  
**EXPRESS TRAVEL TIME SUMMARY**

	Express Travel Times (Hours:Minutes)			
	Staff Recommended (VHS)	Option A (VHS)	Option A (Maglev)	Option B (VHS)
Los Angeles - San Francisco	2:30	2:42	2:00	2:30
Los Angeles - San Jose	2:02	2:13	1:37	2:02
Los Angeles - San Diego <sup>1</sup>	1:03	1:00	0:49	1:00
Los Angeles - Sacramento	2:09	2:20	1:40	2:09
San Francisco - Sacramento	1:40	1:40	1:16	1:40
Fresno - San Jose	0:46	0:46	0:35	0:46
Fresno - Los Angeles	1:19	1:30	1:05	1:19
Fresno - San Francisco	1:15	1:15	0:58	1:15
Bakersfield - San Francisco	1:47	1:47	1:20	1:47
Bakersfield - Los Angeles	0:47	0:58	0:43	0:47
Sacramento - San Jose	1:12	1:12	0:53	1:12

<sup>1</sup> San Diego station is downtown for Staff Recommended, Qualcomm Stadium for others.



**EXHIBIT 4-15**  
**LOCAL TRAVEL TIME/AVERAGE SPEED - VHS**



**EXHIBIT 4-16**  
**LOCAL TRAVEL TIME/AVERAGE SPEED - MAGLEV**







**EXHIBIT 4-17**  
**AVERAGE EXPRESS SPEED - VHS**



**EXHIBIT 4-18**  
**AVERAGE EXPRESS SPEED - MAGLEV**







### 4.3 ENVIRONMENTAL SUMMARY

The following discussion compares the relative potential for environmental impacts of the Staff Recommended Alternative, Option A, and Option B. There are two major differences in the three corridors that had an effect on the overall environmental ranking. The Recommended Corridor would extend along the LOSSAN alignment from San Diego to Los Angeles and the I-5/Grapevine alignment from Los Angeles to Bakersfield. Option A would take the inland route along the I-15/Qualcomm alignment and utilize the Palmdale/Mojave alignment through the Tehachapi's from Los Angeles to Bakersfield. Option B would also utilize the I-15/Qualcomm alignment but take the I-5/Grapevine alignment from Los Angeles to Bakersfield. Rankings of High, Moderate, and Low discussed below and in Table J-7 were used for relative comparative purposes and are not related to potential level of impact. This would have to be fully evaluated in a future environmental document consistent with both the National Environmental Policy Act (NEPA) and the California Environmental Quality Act (CEQA).

#### **Staff Recommended Alternative**

The Staff Recommended Alternative ranked high in potential for environmental impacts as compared to the other corridors.

This corridor is constrained by development beginning in San Diego to Los Angeles along the LOSSAN alignment due to the proximity of the coastline and dense development in San Diego and Orange counties, as well as dense development in Los Angeles County, and Camp Pendleton. From Los Angeles to the Riverside Terminus the corridor would extend along the UP/Metrolink alignment through urban and rural areas in Los Angeles, San Bernardino, and Riverside

counties. The corridor is more constrained in the urban areas. From Los Angeles to Bakersfield via the I-5/Grapevine alignment, the corridor extends through suburban to rural areas. This alignment would result in 28 miles of tunnel through the Tehachapi Mountains. The corridor would extend along the West 99 alignment from Bakersfield to north of Modesto through mostly rural areas and more suburban and urban areas through Central Valley towns and cities. Through Pacheco Pass, the alignment would extend through rural areas and small towns such as Los Banos and San Juan Bautista to a denser urban area around San Jose. Up the Peninsula alignment the corridor is within very dense urban areas all the way to San Francisco following the existing Caltrain route. Demographics along the Recommended Corridor are directly related to the dense development through most of the urban areas. This corridor has the potential to affect a large number of minority and low-income populations as compared to Option A or Option B.

This corridor ranked highest for impacts to threatened and endangered species and habitat as compared to Option A or Option B. The major difference being numerous species located along the LOSSAN alignment particularly bird species near the coastline and adjacent lagoons. This corridor also ranked highest for impacts to water resources due to the coast and lagoons along the LOSSAN alignment. Floodplain encroachment was also highest for this corridor because of the potential for more floodplain crossings associated with the LOSSAN alignment.

The Recommended Corridor ranked the highest overall for potential impacts to parks and recreation. The LOSSAN alignment would potentially affect more parks and recreational beaches than the I-15/Qualcomm alignment. The I-5/Grapevine alignment would also potentially affect more resources than the Palmdale/Mojave alignment including the Angeles National Forest and Castaic Lake Recreation Area. Visual impacts were also ranked high due to the potential for major impacts associated with the LOSSAN alignment, particularly along elevated portions and along beach areas. The I-5/Grapevine alignment would also potentially result in substantial visual impacts at recreational areas and to I-5 travelers. This corridor also ranked highest for potential historic property impacts because the LOSSAN alignment would pass near historic Old Town San Diego and Mission San Juan Capistrano in Orange County.

The potential for encountering hazardous materials/waste sites was ranked as moderate given that the LOSSAN alignment would extend through industrial areas in San Diego, Orange, and Los Angeles counties that are not along the I-15/Qualcomm alignment. The I-5/Grapevine alignment would not have the potential to affect as many hazardous materials/waste sites as the Palmdale/Mojave alignment.

### **Option A**

Overall, the Option A Corridor ranked moderate in potential for environmental impacts as compared to the other corridors.

The Option A Corridor is less constrained by development than the Recommended Corridor. The differences include the San Diego extension to Riverside along the I-15/Qualcomm alignment and the Tehachapi crossing along the Palmdale/Mojave alignment. This corridor would bypass Camp Pendleton and the urban development along the coast and in Orange and Los Angeles counties. Along the Palmdale/Mojave alignment from Los Angeles to Bakersfield there are more developed areas including Palmdale, Lancaster, Rosamond, and areas around southeast Bakersfield. Generally, development along this alignment is more suburban in nature except through the city center.

This corridor has the potential to affect minority and low-income populations but to a lesser extent than the Recommended Corridor given that the I-15/Qualcomm alignment where no minority or low-income populations were identified. This corridor may also result in slightly higher potential to impact populations compared to Option B given that the Palmdale/Mojave alignment extends through more populated areas.

Option A ranked moderate for impacts to threatened and endangered species. The I-15/Qualcomm alignment would not traverse areas that are as sensitive as the LOSSAN alignment. However, this corridor would potentially affect more species than the I-5/Grapevine alignment. This corridor also ranked moderate for impacts to water resources because the I-15/Qualcomm alignment would cross fewer streams than the LOSSAN alignment and would not be near lagoons or the coastline. The Palmdale/Mojave alignment in this corridor and the I-5/Grapevine alignment in the Recommended Corridor and Option B are relatively

equal in the number and scale of the waters adjacent to or crossed by the alignments. Consistent with the water resources, this corridor also ranked moderate for floodplain encroachment. The I-15/Qualcomm alignment would have minor potential for floodplain encroachment as compared to the LOSSAN alignment.

This corridor ranked the lowest for potential impacts to parks and recreation. The I-15/Qualcomm and Palmdale/Mojave alignments would not affect as many parks as the LOSSAN and I-5/Grapevine alignments. Visual impacts were ranked as moderate because the I-15/Qualcomm alignment would not have the major visual impacts associated with the LOSSAN alignment including those along the coast and through portions of San Diego and Orange counties. The Palmdale/Mojave alignment would result in similar visual impacts as the I-5/Grapevine alignment. This corridor also ranked moderate for potential historic property impacts. The I-15/Qualcomm alignment would not affect historic properties in Old Town San Diego or in Orange County.

Option A ranked moderate for potential hazardous materials/waste impacts because the I-15/Qualcomm alignment would not affect the number and type of sites located along the LOSSAN alignment. However, the Palmdale/Mojave alignment would have the potential to affect more sites than the I-5/Grapevine alignment.





### **Option B**

Overall, the Option B Corridor ranked lowest in potential for environmental impacts as compared to the other corridors.

The Option B Corridor is the least constrained by development of all corridors. Like Option A, this corridor would extend along the I-15/Qualcomm alignment but the Tehachapi crossing from Los Angeles to Bakersfield would be along the I-5/Grapevine alignment where there are less developed areas. This corridor would also bypass Palmdale and Lancaster. This corridor also ranked lowest in the potential to affect minority and low-income populations.

Option B ranked lowest for impacts to threatened and endangered species. The I-15/Qualcomm alignment would not traverse areas that are as sensitive as the LOSSAN alignment or the Palmdale/Mojave alignment. The potential for water resource impacts and floodplain encroachment were ranked as moderate because the I-15/Qualcomm alignment would cross fewer streams than the LOSSAN alignment and would not

be near lagoons or the coastline. The I-5/Grapevine alignment in this corridor and the Palmdale/Mojave alignment in Option A are relatively equal in the number and scale of the waters and floodplains adjacent to or crossed by the alignments.

This corridor ranked moderate for potential impacts to parks and recreation. While the I-15/Qualcomm alignment would not affect as many parks as the LOSSAN alignment, the I-5/Grapevine alignment would affect more than the Palmdale/Mojave alignment including the Hungry Valley State Vehicular Recreational Area, Pyramid Lake Recreation Area, and Castaic Lake Recreation Area. Visual impacts were also ranked as moderate because the I-15/Qualcomm alignment would not have the major visual impacts associated with the LOSSAN alignment and, the I-5/Grapevine and Palmdale/Mojave alignments would have similar visual impacts. Option B ranked moderate for potential historic property impacts. The I-15/Qualcomm alignment would not affect historic properties in Old Town San Diego or in Orange County.

This corridor ranked lowest for potential hazardous materials/waste impacts. The I-15/Qualcomm and I-5/Grapevine alignments would not affect the number and type of sites located along the LOSSAN and Palmdale/Mojave alignments.

# OPERATING STRATEGY DEVELOPMENT

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# V - OPERATING STRATEGY DEVELOPMENT

This section describes the overall strategy and specific parameters assumed for the potential HSR service in California. The opportunities and constraints associated with operating these HSR services are also outlined. This operating strategy was used as the basis for the estimation of operating and maintenance costs contained in this report and the ridership and revenue forecasts that were prepared by Charles River and Associates. An initial conceptual plan was developed for use in evaluating a number of different corridors, which was then refined to reflect changing alignments and stations as well as to improve the forecasted ridership and revenue. The conceptual service plan presented is applicable to the statewide corridors in this study (see Chapter 4), although the stations vary based on alignment. Specific scheduling and operations modeling analysis and further iterations of testing the operating assumptions with demand forecasting models will be required prior to implementation.

## 5.1 CAPACITY

An examination of the *Baseline* Conceptual Operating Plan reveals that the infrastructure to be created by the High Speed Rail Authority would have a great deal of underutilized capacity. Capacity exists for more frequent trains and in periods of the day when portions of the guideway are not used. Clearly, there must be demand present to justify the additional service; however, it is important to mention the extent of capacity that would be available on the intercity system. One of the benefits of fixed-guideway public transport modes is the ability to adjust the number of trains occupying the guideway as demand increases. The infrastructure has two important attributes to focus on: it is expensive to create and it provides a very fast path between points it serves. In order to take advantage of the speed it offers, the markets it serves can be expanded to provide for every potential market that could take advantage of the infrastructure without compromising the quality of overall service.

When other examples of high-speed operations are examined, a pattern of use dramatically greater than the conceptual operating plan is illuminated. In Japan, for instance, the main Shinkansen route has trains being dispatched for the main station in Tokyo every four minutes, almost throughout the day. This equates to 280 daily trains serving 1,200 persons per train. On the Paris-based high-speed network, trains are dispatched on a similar schedule for significant por-

tions of the day. Over 1,000 persons can be accommodated per train on the TGV lines in France when two trains are coupled together. These systems use sophisticated train control technology, which will also be available to the California high-speed system, to safely control train spacing and provide high capacity.

Capacity is expressed in terms of spacing trains along the guideway in order to provide for safe stopping of a following train if the preceding train slows down or stops. The space between trains is the headway or train separation. For instance, a three-minute headway means at the dispatch points trains can originate three-minutes apart. Along the line, a three-minute headway means that at track speed (the speed permitted on the section of track) trains can be spaced three minutes apart safely. At intermediate stations, where additional tracks are available to permit trains to pass the station, a train can be dispatched almost immediately after another train has passed the station since its acceleration to the main track provides the time to maintain the appropriate spacing.



It is useful to compare the capacity of a dual track HSR system to the capacity of existing freeways as a point of reference. Assuming a three-minute train separation and 650 passengers per train, the HSR system has approximately the same capacity as a twelve lane freeway section operating at average vehicle occupancy rates. *Exhibit 5-1 and 5-2* show the assumptions and calculation of this comparison. In both Japan and France trainsets are operated with capacities of up to 1000 to 1300 passengers at similar train separation times, nearly doubling the capacity of the proposed system.

**EXHIBIT 5-1**  
**CAPACITY OF THE HSR SYSTEM**

Number of Passengers/Train	Number of Train/Hour (Both Directions) <sup>1</sup>	HSR Passenger Capacity/Hour
650	40	26,000
1300	40	52,000

<sup>1</sup>) Assumes 3 Minute Spacing

**EXHIBIT 5-2**  
**HIGHWAY OF EQUIVALENT CAPACITY**

Number of Passengers/ Hour	Capacity of 1 Lane/Hour (Cars)	Car Passengers/ Load Factor	Car Passengers/ Lane/Hour	Number of Lanes
26,000	2000	1.1	2200	12
52,000	2000	1.1	2200	24



## 5.2 REFINED CONCEPTUAL OPERATING/SERVICE PLAN

Based on the operating concept (baseline) applied in the commissions previous studies, conceptual operating plans were developed in conjunction with high-speed rail ridership forecasts, reflecting service requirements in the San Diego, Los Angeles, San Francisco Bay Area, and Sacramento corridors. As preliminary ridership forecasts were refined the operating plan was also adjusted to achieve a more appropriate level of service – this was an iterative process between the ridership plan and the corridor evaluation studies. The conceptual operating plan was also refined as corridor options were narrowed. As with the baseline operating plan, this refined plan still assumes trains with a capacity of 600 to 650 passengers operating with at least a 65 percent occupancy rate. No formal dispatch/operating models or simulations were applied to develop this conceptual operating plan.

The basic service pattern would be between 6:00 a.m. and 8:00 p.m. for most trains between Los Angeles and San Francisco, with some trains starting or finishing trips beyond these hours. To augment the basic service, trains are added in the peak periods and some trains in the basic pattern make extra stops. Additional suburban-express trains are inserted into gaps in the basic schedule during the peaks. The extra stops suburban-express trains make are made to serve residents of suburban communities who have a destination at the far end of the route. These trains function as express trains through the central valley and as local trains through major urban areas.

In addition to increasing suburban-express service and modifying stopping patterns, new regional services were added to assumed baseline operating plan. The regional services would provide regular service between Sacramento and the San Francisco Bay Area throughout the day. They would also provide service from the Central Valley to the Bay Area. By using trains that originate in the Central Valley these regional services would offer earlier morning access to northern and southern California.

For statewide intercity service, sixty-four weekday trains in each direction were assumed in the conceptual operating scenario based on Year 2020 forecasts. The intercity trains are comprised of four service categories:

- ◆ Express (20 trains/direction/day) - Trains running from either Sacramento, San Jose or San Francisco to Los Angeles and San Diego without intermediate stops.
- ◆ Semi-Express (12 trains/direction/day) - Trains running between similar endpoints as the express, with intermediate stops at major Central Valley cities such as Modesto, Fresno and Bakersfield.
- ◆ Suburban-Express (20 trains/direction/day) - Trains running “local “ during both the beginning and the end (LA or Bay Area) of the trip while running express through the intermediate points.
- ◆ Local (12 trains/direction/day) - Trains stopping at all intermediate stops with potential for skipping stops to improve service depending on demand.

For regional service, twenty-two weekday trains in each direction were assumed in two service categories:

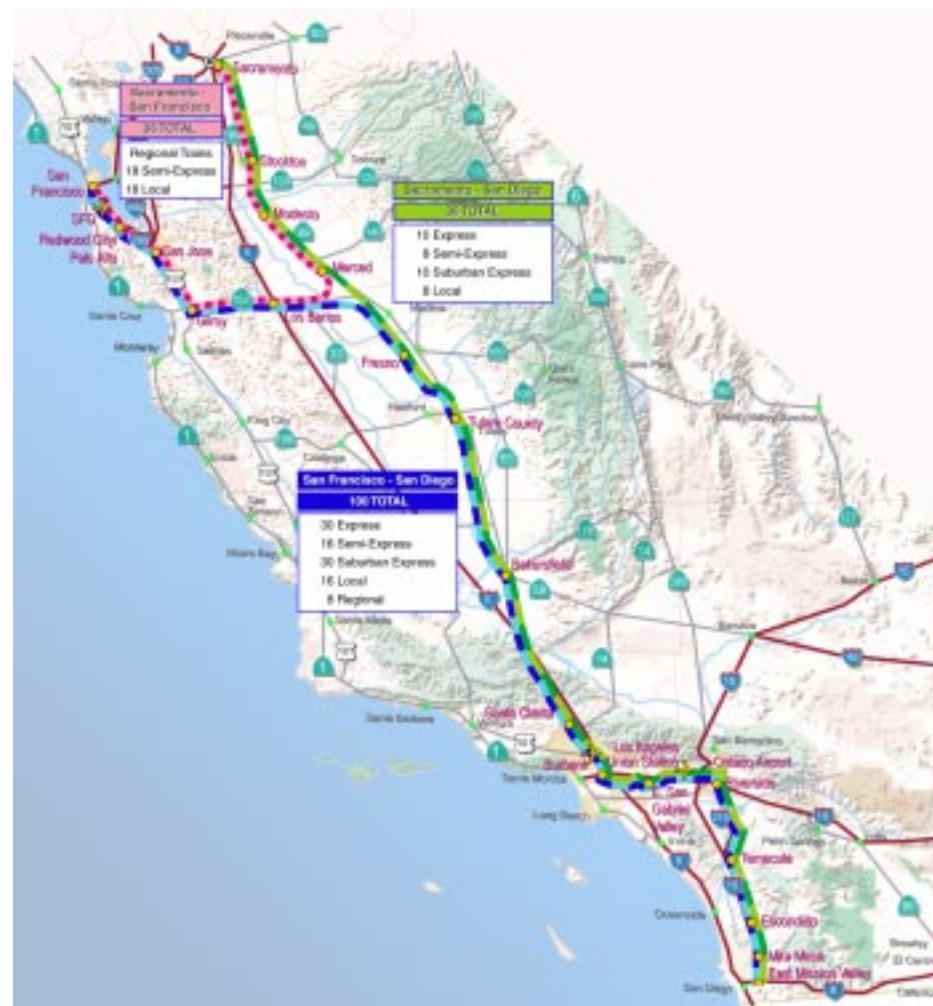
- ◆ Semi-Express (8 trains/direction/day) - Trains running between Sacramento and San Francisco, making limited stops at intermediate stations.
- ◆ Local (14 trains/direction/day) - Trains running between San Francisco or Los Angeles and San Diego to stations in the middle of the corridor such as Fresno or Bakersfield as well as between the northern terminus of San Francisco and Sacramento. These trains would stop at all intermediate stops with potential for skipping stops to improve service to stations with highest demand.



**EXHIBIT 5-3  
CONCEPTUAL OPERATING PLAN**

Complicating the service plan for the high-speed network is the potential for multiple terminal stations. The major northern California terminal is San Francisco, however, the proposed corridors that were studied allowed for additional terminal stations at San Jose, Oakland and Sacramento. The Authority recommended corridor accesses the Bay Area via the Pacheco Pass and has northern terminals at San Francisco and Sacramento only. The major southern terminal is Los Angeles, however, trains will also serve San Diego. Of sixty-four northbound intercity trains, fifty-three daily trains would originate from San Diego through while the balance would originate in Los Angeles. *Exhibit 5-3* illustrates the total number of trains on each of the HSR lines.

The refined conceptual service plan, which was developed to account for a variety of routing combinations and technologies, is included in Appendix C.







of statewide weekday train service at potential station locations throughout the corridor, assuming future implementation of the overall system. While this scenario is based on the conceptual operating plan of daily train frequencies and stopping patterns, it does not represent optimal train timing/scheduling. The example schedule has not been tested or modeled in a simulated operating environment. Extensive operations modeling analyses and consideration of various points-of-view will be required before schedules can be verified or even considered as viable draft schedules for use on the proposed system.

**EXHIBIT 5-4**  
**EXAMPLE WEEKDAY TRAIN SCHEDULE - YEAR 2016**

North Regional Service (SAC-SF)

Train Number Service Type	1 L	2 L	3 S	4 L	5 S	6 S	7 L	8 L	9 S	10 S	11 L	12 L	13 L	14 S	15 S	16 L	17 S	18 S
<b>Sacramento</b>	<b>525</b>	<b>610</b>	<b>700</b>	<b>800</b>	<b>915</b>	<b>1000</b>	<b>1005</b>	<b>1045</b>	<b>1100</b>	<b>1220</b>	<b>200</b>	<b>300</b>	<b>400</b>	<b>525</b>	<b>615</b>	<b>735</b>	<b>820</b>	<b>930</b>
Stockton	547	632	▼	822	▼	▼	1027	1107	▼	▼	222	▼	422	▼	▼	757	▼	952
Modesto	559	644	▼	834	▼	▼	1039	1119	▼	▼	234	▼	434	▼	▼	809	▼	1004
Merced	616	701	▼	851	▼	▼	1056	1136	▼	▼	251	▼	451	▼	▼	826	▼	1021
Los Banos	633	718	▼	908	▼	▼	1113	1153	▼	▼	308	▼	508	▼	▼	842	▼	1038
Gilroy	649	734	▼	924	▼	▼	1129	1209	▼	▼	324	▼	524	▼	▼	859	▼	1054
San Jose	704	749	812	939	1027	1112	1144	1224	1212	132	339	412	539	637	727	914	932	1109
Redwood City	720	805	▼	955	▼	▼	1200	1240	▼	▼	355	▼	555	▼	▼	930	▼	1125
SFO	731	816	▼	1006	▼	▼	1211	1251	▼	▼	406	▼	606	▼	▼	941	▼	1136
<b>San Francisco</b>	<b>745</b>	<b>830</b>	<b>845</b>	<b>1020</b>	<b>1100</b>	<b>1145</b>	<b>1225</b>	<b>105</b>	<b>1245</b>	<b>205</b>	<b>420</b>	<b>445</b>	<b>620</b>	<b>710</b>	<b>800</b>	<b>955</b>	<b>1005</b>	<b>1150</b>



### 5.3 EXPRESS COMMUTE SERVICE ANALYSIS

With its focus on longer distance intercity travel, the baseline conceptual operating/service plan leaves some gaps in service. During the morning and evening peak periods, there were few trains serving the potential markets for business and work (commute) travel. The first statewide intercity trains to arrive in Northern or Southern California from the other end of the corridor arrive between 8:00 and 9:00 am. While some regional service was planned during these early morning hours, there was a significant amount of capacity available for additional commute services.

Specific studies were completed to evaluate the merit of express commuter services that could be provided on VHS or Maglev alignments serving San Diego, Los Angeles, and Bay Area (San Francisco, San Jose, and Oakland) urban centers. Basic route definition, travel time estimates and operating assumptions have been developed by the Corridor Evaluation team to support travel demand forecasting analyses prepared by Charles River Associates (CRA) and the local Metropolitan Transportation Authorities. It is necessary to compare the revenue estimates against the associated capital, operations and maintenance costs in order to evaluate the merit of the proposed express commuter services

#### Parameters of Express Commute Service

The proposed express commuter services are defined such that the services would be provided by HSR compatible trains that travel at speeds similar to the local intercity service, with stops at all the HSR stations within potential commute range of each metropolitan area. These commute services would be operated on the proposed HSR intercity infrastructure including track and stations without additional infrastructure improvements or related costs. Capital expenditures

would be limited to any additional rolling stock needed to provide this service. Additional rolling stock would need to be compatible with the intercity rolling stock, yet they would not necessarily need to have the same capabilities or passenger accommodations. The commute segments of the HSR system typically do not have operating speeds over 125 – 150 mph. Thus, the commute rolling stock could have lower speed capabilities than the intercity rolling stock.

As with the intercity system, both VHS and Maglev systems were evaluated, however, for the purposes of this report, only the VHS technology is presented. At each station, 4 trains would be provided per hour of peak period service. Three-hour a.m. and p.m. peak periods were assumed. A two-minute dwell time was assumed at each intermediate station.

The express commuter routes are defined below for each metropolitan area in terms of alignment and station locations. The results of the ridership and revenue forecasting are documented in the [Task 6 Report: Express Commuter Ridership and Revenue Forecasts on High-Speed Rail Alignments](#) by Charles River Associates.



### San Diego Area

Forecasts were made for three different HSR alignment alternatives for San Diego. *Exhibit 5-5* shows the three possible alignments. Only one of these alignments would be used for the HSR line, and thus be available for the commuter service.

- ◆ Coast: Oceanside to San Diego (Santa Fe Depot), with an intermediate station at Solana Beach.
- ◆ State Route (SR) 52: Temecula to San Diego (Santa Fe Depot), with intermediate stations at Escondido and Mira Mesa.
- ◆ Stadium: Temecula to QUALCOMM Stadium, with intermediate stations at Escondido and Mira Mesa.

The Coast alternative would follow the LOSSAN corridor. While the alignment parallels the Coaster service operated by the North County Transit District (NCTD) and shares three stations with it, this alternative would not stop at the Carlsbad Village, Carlsbad Poinsettia, Encinitas, Sorrento Valley, and Old Town Transit Center stations.

The SR 52 alternative would begin in Temecula (in the southern portion of Riverside County) and follow the I-15 corridor south to Escondido and then to Mira Mesa. The rail line would continue south along I-15 to SR 52 and turn west along the SR 52 corridor. It would turn south along the LOSSAN corridor and terminate at the Santa Fe Depot, in downtown San Diego.

The Stadium alternative is similar to the SR 52 alternative above, except that from Mira Mesa the rail line would continue south along I-15 terminating at QUALCOMM Stadium, at the intersection of I-15 and I-8.

EXHIBIT 5-5  
EXPRESS COMMUTE CORRIDORS (SAN DIEGO)



**EXHIBIT 5-6**  
**EXPRESS COMMUTE CORRIDORS (LOS ANGELES)**



### **Los Angeles Area**

For the Los Angeles region, forecasts were made for three different lines, all of which could be part of the HSR system. *Exhibit 5-6* shows the three possible commuter lines.

- ◆ Orange County: Oceanside to Los Angeles (Union Station), with intermediate stations at Irvine, Anaheim, and Fullerton.
- ◆ Riverside County: Temecula to Los Angeles (Union Station), with intermediate stations at Riverside, Ontario, and East San Gabriel.
- ◆ Los Angeles County: Palmdale to Los Angeles (Union Station), with intermediate stations at Santa Clarita and Burbank. If the grapevine alternative is used for the Tehachapi Crossing this line would terminate at Santa Clarita.

The Orange County alternative would operate in the LOSSAN corridor and serve Metrolink stations at Irvine, Anaheim, Fullerton, and Union Station. To maintain its status as a high speed line, it would not stop at four intermediate Metrolink stations (Santa Ana, Orange, Norwalk, and Commerce).

The Riverside County alternative is similar to Metrolink's Riverside Line but would begin about 36 miles south of Riverside in Temecula. To maintain its status as a high speed line, it would not stop at three intermediate Metrolink stations (Pedley, Industry, and Montebello/Commerce).

The Los Angeles County alternative would begin in either Palmdale or Santa Clarita, depending on the Tehachapi Crossing alignment. To maintain the high speed service, current Metrolink Antelope Valley Line stops would not be made at Acton, Princessa, Sylmar, and Glendale.





### San Francisco Bay Area

For the Bay Area, three different alternative alignments were tested as shown in *Exhibit 5-7*.

- ◆ Altamont Pass : Modesto and Stockton to San Francisco (Transbay Terminal) and San Jose, with intermediate stations at Tracy, Pleasanton, Newark, Redwood City, and Millbrae/SFO.
- ◆ Pacheco Pass : Los Banos to downtown San Francisco with intermediate stations at Gilroy, San Jose, Redwood City, and Millbrae/SFO.
- ◆ East Bay : Los Banos to West Oakland with intermediate stations at Gilroy, San Jose, Newark (Union City), and Oakland International Airport.

In the Altamont Pass alternative, trains would branch at Newark, with half the trains going north to San Francisco and half going south to San Jose. To maintain its status as a high speed line, this service would not stop at a number of Caltrain stations. This alternative uses the Commission's Baseline HSR right of way.

The Pacheco Pass alternative is very similar to Caltrain's alignment except that service would start in Los Banos, about 34 miles east of Gilroy. The service terminus would be at the Transbay Terminal rather than at 4<sup>th</sup> & Townsend Street currently used by Caltrain. To maintain its status as a high speed line, it would not stop at a number of Caltrain stations.

The East Bay alternative uses the Pacheco Pass alignment and serves the East Bay. Service would still start in Los Banos but from San Jose would proceed up the East Bay to Newark, Oakland Airport, and West Oakland.

EXHIBIT 5-7  
EXPRESS COMMUTE CORRIDORS (BAY AREA)





## **Express Commute Cost Analysis**

The capital, operations and maintenance costs for this service have been developed for the commuter lines corresponding to Authority Options A and B. Only. This costing analysis was based on two different operating scenarios to present a range of the potential expenses. Both operating scenarios assume the Stadium route in San Diego, the Los Angeles and Riverside County routes in Los Angeles and the Pacheco route to San Francisco in the Bay Area (Authority Option A and B corridors as defined in the preceding chapter). First, we estimated the costs associated with operating the service using vehicles other than the HSR intercity trainsets. This service would still be integrated into the daily intercity operations but would be distinct in terms of the vehicles used (not the same vehicles used for the intercity service). Second, we estimated the amount of express commute passengers that could be served by utilizing any available capacity of intercity trains with added commuter capacity and only proposed operating separate vehicles for the demand not served by the available intercity capacity. These two scenarios are described below.

### **Separate Vehicles Scenario:**

This scenario assumes operating the commute service using vehicles separate from the HSR intercity trainsets. The service would still be integrated into the daily intercity operations but would be distinct in terms of the vehicles used. The capital cost estimate for this scenario includes all of the required trains to operate the service at the assumed frequencies. All trains assumed for the commute service were included in the operations and maintenance cost estimate for the commute services. The cost of operations and maintenance is much higher on a per train-mile basis for these commute services versus the longer distance intercity service. It is assumed that the intercity service primarily pays for the maintenance of the infrastructure (line and stations) used by the commute service, while the commute service just pays for the additional maintenance required due to its operation.

### **Integrated Scenario:**

The primary assumption of this scenario is that a certain portion of the express commute passengers can use available capacity on the proposed intercity trains with added commuter capacity. The added commuter capacity consists of an additional coach in each of the intercity trainsets that would be used for commuter services. However, this must be limited to trains that traverse the corridor in the appropriate direction during the peak period and stop at each local station. There-

fore the analysis considered only local, suburban express and regional-local trains that meet the requirements of directionality and timing. Intercity express and semi-express trains were not considered for this analysis. Based on information from CRA regarding the estimated load factor of locally oriented intercity trainsets during the peak periods, we estimated the quantity of available capacity that could be used by commute passengers including the additional coaches. To the extent that local intercity trains could carry express commute passengers and maintain the assumed frequency of the commute service, a portion of the commute passenger demand is assumed to be accommodated on these intercity trains. The remaining commute passenger demand must be accommodated on separate express commute trains. Intercity trains not used for commuter services were not included in the commute operations and maintenance cost, since they are included in the intercity estimate. The estimated load factors and available capacity calculations are presented in *Appendix J*.

This scenario also assumes that the intercity fare structure can accommodate the shorter length commute trips, so that the assumed ridership and revenue in the CRA analysis can be achieved. At present, the ridership and revenue forecasts are based on different fare structures; \$20 minimum boarding fee for intercity travel and \$5 minimum boarding fee for commute travel.

### **O&M Cost Estimates**

The approximate costs of operating and maintaining a commute service as part of the overall intercity operating strategy have been estimated in terms of annual costs. These cost estimates are based on operating, ridership and revenue assumptions and analysis that have not been optimized in terms of frequency,



capacity and demand. These costs should be considered preliminary and approximate and should be used only as a relative measure of the cost associated with operating such a service.

A breakdown of the unit costs associated with the operation and maintenance of both the intercity and express commute services is included in *Appendix J*. The unit cost elements are further defined in the Task 2.0 Technical Memorandum regarding assumptions and parameters.

The total annual O&M costs for the express commute service on each commuter line for both Separate and Integrated scenarios are included in *Appendix J* and summarized in *Exhibit 5-8*. The number of additional trains required for the commute service is also presented for both scenarios.

### **Capital Cost Estimates**

Capital costs were estimated based on the vehicles required for each operating scenario and annualized for comparison purposes. The costs assume a commute trainset that is compatible with the intercity rolling stock for mixed use purposes but not necessarily the same in terms of performance capabilities. The number of vehicles required for the Separate Vehicle Scenario was based on the operating frequency assumptions, travel times, reasonable turn around times and a 20% maintenance/spare ratio. For the Integrated Scenario the number of was adjusted to account for the available capacity on locally oriented intercity trains. The capital cost estimates are included in *Appendix J* and summarized in *Exhibit 5-8*.

### **Conclusions**

The analysis indicates that operating the express commute service with separate vehicles (separate scenario) will clearly cost more in terms of vehicle procurement (\$64-\$71 million/year) and operations and maintenance (\$113-\$126 million/year) than it can generate in revenues (\$70-\$84 million/year). By integrating the commute service with the planned intercity operations and sharing capacity, the costs of vehicle procurement can be reduced to (\$20-\$23 million/year) and operations and maintenance can be reduced to (\$32-\$42 million/year). A summary of estimated capital, operations and maintenance costs compared to estimated revenue is presented in *Exhibit 5-8*. The revenue estimates were provided by Charles River Associates.

**EXHIBIT 5-8**  
**EXPRESS COMMUTE SERVICE- ANNUAL COST COMPARISON**

Option	Service Scenario	Annual O&M	Annual Capital	Total Annual Cost	Total Annual Revenue <sup>1</sup>
Option A	Separate	\$ 126,040,919	\$ 70,928,000	\$ 196,968,919	\$ 84,396,000
	Integrated	\$ 41,779,754	\$ 64,549,254	\$ 64,549,254	\$ 84,396,000
Option B	Separate	\$ 113,111,090	\$ 64,480,000	\$ 177,591,090	\$ 69,546,000
	Integrated	\$ 31,853,693	\$ 19,545,500	\$ 51,399,193	\$ 69,546,000

1) From Charles River Associates

# IMPLEMENTATION



# VI - IMPLEMENTATION ISSUES

## 6.1 PROJECT STAGING/PHASING

This section outlines the general “blue print” for the scope, timing and expenditure assumptions for the implementation of the Authority Recommended System in terms of environmental review, engineering design and construction process. Because of the complexity and scale of the project, the recommended plan for implementation is outlined below in two primary phases covering a total of 16 years from start of the environmental process to full operation. However, specific revenue producing segments could be completed and opened for revenue service earlier in the 16-year implementation schedule.

### **Environmental Review Process**

Because of the geographic complexity of the project and the number of alternative corridors and station locations developed as part of this corridor evaluation, staff is recommending that the environmental review process for subsequent project development be phased to coincide with engineering design. The objective of the next phase of work is to initiate the formal environmental process to engage public agencies and the interested public in the process of alternatives planning and evaluation.

The environmental process as prescribed in the National Environmental Policy Act (NEPA) and the California Environmental Quality Act (CEQA) is designed to actively engage resource agencies and the public in the evaluation of alternatives to enable informed decisions early in the planning process prior to project approval. Initiating the formal NEPA/CEQA process to analyze each of the conceptual corridor alternatives recommended by the Authority in July 1999 will bring the planning process to a point that feasible corridor rights-of-way can be preserved for subsequent detailed engineering design, focused environmental analyses and ultimately implementation.

### **Program Environmental Document and Conceptual Engineering**

Considering the extent of alternative corridors to be analyzed, the appropriate environmental document for the next phase of project development is a Program Environmental Impact Report/Environmental Impact Statement (EIR/EIS). The advantages of a Program EIR/EIS as described in Section 15168(b) of CEQA are:

- ◆ Provision for a more exhaustive consideration of impacts and alternatives than would be practical in an individual EIR/EIS.
- ◆ Focus on cumulative impacts that might be slighted in a case-by-case analysis.
- ◆ Avoidance of continual reconsideration of recurring policy issues.
- ◆ Consideration of broad policy alternatives and programmatic mitigation measures at an early stage when the agency has greater flexibility to deal with them.
- ◆ Reduction of paperwork by encouraging the reuse of data through subsequent tiering.
- ◆ The Program EIR/EIS would also allow the Authority to preserve corridors and alignments for future implementation.

Although the legally required contents of a Program EIR/EIS are the same as those of a project-level document, in practice there are considerable differences in the level of detail provided because of the general nature of the programs being evaluated. Program-level documents are typically more general in the discussion of resources and impacts. Courts have indicated that a program-level document may contain a more general discussion of alternatives, impacts, and mitigation measures. This scenario suits the California's high-speed-rail project at this stage of planning and design and will allow for decisions to be made concerning corridors and alignments for subsequent engineering detail and focused environmental analyses.

The program-level environmental process will focus on the analysis of each of the corridor alternatives to identify alignments that local, state, and federal agencies, with approval or permit responsibilities, consider fea-





sible and to identify alignment alternatives that minimize public resistance. An Agency Advisory Committee composed of each of the resource agencies in the three main regions of the state (Northern California, Central California and Southern California) would be formed and meet monthly to review the environmental information and identify alignments that would avoid or minimize potential impacts or policy conflicts. The Agency Advisory Committee group would also discuss mitigation measures that can be included in project planning and design. Typical agencies that would be included in the Agency Advisory Committee include: U.S. Army Corps of Engineers, FHWA, FAA, FRA, U.S. Fish and Wildlife Service, U.S. Department of Agriculture, EPA, State Air Resources Board, California Public Utilities Commission, California Department of Parks and Recreation, California Department of Fish and Game, State Historic Preservation Officer, California Water Resources Board, and Caltrans. Regional and local transportation planning organizations should also participate.

A proactive public involvement program would be a formal part of the Program EIR/EIS and focus on scoping, identification of issues and concerns, and consensus building. In addition to the formal NEPA public scoping process and public hearing, frequent informational workshops would be held throughout the state to discuss alternatives. Continuation of the HSRA Web Site and Newsletters will help keep the public informed and involved in the planning and environmental process. Reaching consensus on alternatives will be one of the main objectives of the Program EIR/EIS.

Conceptual engineering analysis would be completed

in this phase of study to support the identification of impacts and proposed mitigations necessary in the program-level environmental document. In addition, alignment and station locations would be further defined in terms of right-of-way for possible preservation and/or local land use policy actions. To meet this objective, each of the alternatives adopted by the Authority for further consideration will have to be developed to a conceptual level (five- to ten-percent of engineering design). During this phase of study a project phasing or staging plan should be developed to identify high priority revenue segments for implementation.

Based on previous experience with similar corridor studies, staff estimates that the this phase of conceptual engineering and environmental analysis (to prepare a Program EIR/EIS) will take about two years and cost about \$15 to \$20 million (1999 dollars).

In summary, the key objectives of the program-level environmental document and conceptual engineering process are to conduct analyses (consistent with the level of engineering design), implement the formal public and agency involvement process, build consensus, and provide a solid base for more focused analyses. At the end of the Program EIR/EIS phase, the Authority will have the required technical analyses and public input to make an informed decision on alignment alternatives to be carried forward to more detailed engineering and focused environmental analysis for the project-specific environmental document. The Program EIR/EIS will also provide sufficient analyses for the Authority to eliminate infeasible alternatives. The state Notice of Determination (NOD) and federal Record of Decision (ROD), signifying the completion of the Program EIR/EIS, will identify a preferred corridor for study in project-specific environmental documentation.

#### **Project Specific Environmental Process and Preliminary Engineering**

The subsequent project-specific environmental documentation and preliminary engineering could be initiated on either the entire system or on portions/segments of the system as deemed appropriate to meet the objectives of the project-staging plan. Subsequent environmental documents on portions of the system would tier off of the Program EIR/EIS, focusing only on those topics and resources that require further analysis to address local issues and site specific impacts.

Cumulative and general issues would be taken care of.

The Project EIR/EIS and associated Preliminary Engineering studies for the Preferred Corridor is estimated to have a duration of four years and a cost of approximately \$350 million (1999 dollars). During this four-year period the following tasks would be accomplished:

- ◆ Project specific environmental technical analyses and documentation on preferred corridor alternative and stations,
- ◆ Obtain necessary approvals and permits for system implementation/construction,
- ◆ Formal public and agency involvement and agency coordination,
- ◆ Preliminary engineering sufficient for the detailed environmental analysis, agency approvals and the design-build procurement process (15 to 30-percent level of engineering design),
- ◆ Prepare procurement documents for design-build contracts for civil/line construction and design-build-operate-maintain (DBOM) contracts for systems construction and operations and maintenance, and
- ◆ Finalize Project Phasing/Staging Plan developed during the program environmental stage.

### **Design and Construction**

A design-build approach is assumed for the procurement of the system. This design-build process would consist of multiple contracts for the civil works by segment and/or station area and a separate contract for the systems (power distribution, track and train control). Assuming a Design-Build procurement approach, the period of design and construction is estimated to be ten years for full completion of the system. The cost of construction as estimated earlier in this report is approximately \$25 to \$26 billion depending on the selected corridor alternatives, assuming the VHS technology. While financing would be secured for the system as a whole, the construction activities would be staged by segment due to the large size of the project and the resources required. Construction of the entire system would be completed through simultaneous construction of segments. The staging of each segment will be based on its relative revenue potential as a stand-alone segment and its readiness for construction.

Tables presenting very rough estimates of the annual expenditures by element over the next 16 years assuming the Authority's Recommended System (Option A and B) are included in the Appendix. The estimates of expenditures were developed for use as a guideline for preparing financial scenarios for the business plan and will require further review and detailed study in terms of construction activities and segment phasing prior to implementation. These tables are based on the general timing and scope assumptions outlined above for the environmental and engineering stages of the project. Expenditure plans were prepared for two different phasing options. The first assuming the completion of segments from Los Angeles to San Diego and Merced to Sacramento in the first four years followed by completion of the core segment. The second assumes the completion of the core segment from Los Angeles to San Francisco at the end of the seventh year and the completion of other peripheral segments by the end of the tenth year clearly, the optimum staging will need to be analyzed carefully during the program environmental stage. More detailed phasing/staging plans and schedules will be further defined during the environmental and preliminary engineering phase of the project.



## 6.2 INSTITUTIONAL PLANNING

As the Authority moves towards implementation, it may continue its outreach activities to develop new business arrangements with the current public transit operating organizations it will interact with. These will primarily be organizations that will provide feeder and coordinated transit services for customers and agencies that own rights-of-way, which will be used by the Authority to construct the high-speed infrastructure.

### Coordination

One important objective of the Authority is to focus on customer convenience and to maximize the coordination among the available modes of transportation. The Authority can develop a series of measures designed to make use of the overall network as "seamless" as possible. To this end, the Authority may develop a series of agreements with local and regional transit systems, which will improve coordination of services and take into account every possible action to maximize customer convenience and system effectiveness. The Authority could enter into Coordination Agreements with every public transportation provider that provides an opportunity to feeding the high-speed train system. At each proposed station along the corridor various existing entities provide bus, rail transit or passenger railroad services. The list of entities is large and includes almost every transit system in the State of California.

These agreements would address improving access to information, developing integrated fare systems, designing convenient physical transfers, marketing, coordinating service and schedules, etc. This series of arrangements could become a model for improving transit system connectivity and customer convenience.

### Use of Rights-of-Way

With respect to the use of rights-of-way, the Authority will develop agreements that cover the issues that arise in designing, constructing and operating its infrastructure. These agreements will intensify the Authority's business relationships with the other agencies in California providing rail passenger services. The arrangements will build a strong relationship among the agencies and help to unify their approach to provide the highest level of services for Californians. These arrangements will also offer additional possibilities to assure that the high-speed system is well integrated with the regional services that already exist and assure that the construction of the high-speed system can take place without disrupting current services.

These agreements will cover the issues arising out of any design and construction activities when the Authority alignment requires use of a right-of-way owned by an existing passenger rail (or freight rail) operator. These agreements will also cover transfer facilities, schedule and service coordination, safety, access and other issues. The benefits of these agreements will include improved services for high-speed and regional and local transit systems. Agreements may be required with the Peninsula Corridor Joint Powers Board (Caltrain), the Union Pacific Railroad (UP), the Burlington Northern Santa Fe Railroad (BNSF), the San Diego Northern Railroad (Coasters) and the Southern California Regional Railroad Authority (Metrolink). A listing of local and regional agencies that will interact with the Authority as it implements the high-speed project is attached.

### 6.3 IMPLEMENTATION OF FREIGHT SERVICES

The Authority can enhance its revenues and increase the utility of the high-speed infrastructure by establishing special freight services. Such services will be a new transportation product in the marketplace and will not compete with existing railroad freight services. Two types of freight service are possible including light small package and container shipments which can be accommodated in special cars which can mixed into passenger trains and medium weight shipments which can be accommodated in special freight rolling stock adhering to the design standards and operating requirements of the high-speed infrastructure.

In order to develop these freight services the Authority can work with the private sector to establish joint ventures or franchise arrangements. In addition to increasing the utility of its infrastructure investment, the establishment of freight services will improve the Authority's financial position by establishing additional revenues. As part of the Authority's financial planning, investigation of the marketing potential for these services is underway. The steps the Authority can take should minimize the Authority investment while maximizing the competitive process and the open involvement of the private sector.

The Authority will potentially derive revenue from the use of its property for any required freight handling facilities and from the use of the infrastructure for freight operations. The framework for such an undertaking would provide for a freight operator to plan, develop, invest and operate the freight business and make any required arrangements for transportation to and from trains.

#### **Partnerships**

The Authority can seek and enter into a partnership with a freight transportation operator to establish the service. A partnership permits the Authority to create a new business within its domain and work with an existing service provider to bring in their expertise, experience and familiarity with the market. Such a partnership could be a separate company with its own financial arrangements to assure that only private sector funds are used to invest in business planning, design, facilities, operating, rolling stock, marketing, labor, and other costs of establishing and operating the business. The freight operator would pay a fee to the Authority for use of its tracks and property and for the operations and maintenance services it would receive. The Authority could seek a partner through

an open process that invites any potential partner to discuss terms, conditions, financial arrangements, etc. with the Authority and results in a negotiated arrangement at the discretion of the Authority. In this way the Authority could share in revenues and be shielded from liabilities and risks.

#### **Freight Franchise**

The Authority could also establish a competition for the right to use and occupy its right of way for freight transportation purposes and select a single carrier or multiple carriers who would each be responsible for their own rolling stock, facilities, etc. The franchise approach would maintain a distance between the freight operator and the Authority and maintain the Authority's position as right-of-way owner and service sponsor. This would be consistent with the passenger DBOM approach.